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THE SCIENTIFIC MONTHLY

EDITED BY J. McKEEN CATTELL

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Note.—The new revision of Allen's Analysis is well under way. Volume I is enlarged on the former edition by 220 pages, which is an indication of the great extent of improvement made in recent years. Volume II is enlarged over the former edition by 286 pages. The editors have attracted prominent men in many lines of chemical industry to collaborate in the preparation of the new Allen. The complete work will comprise 9 volumes. Volumes I, II, and III are published. Volume IV is all in type and there is every indication that the other volumes will follow at short intervals.

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THE SCIENTIFIC MONTHLY

APRIL, 1925

CAN LIFE EXIST ON MARS?

By Dr. W. W. COBLENTZ

BUREAU OF STANDARDS

WHAT of Mars? Can the astronomers find out? Thus ran the headlines of the daily press this past summer. Many were the questions asked: Has Mars an atmosphere; what are the white polar caps; is the surface sufficiently warmed to support life? The popular idea seemed to prevail that Mars was a beautiful orange-colored ball rolling toward us until August 22, when it would suddenly disappear from view. Hence, the importance of trying to learn some of its secrets on this bewitching night.

On the other hand, the astronomer saw no need of being excited on this date. A shortening of the distance between the earth and Mars by a few hundred thousand miles was of less importance to him than good seeing over a prolonged interval of time, so that he could trace the seasonal changes in the markings of the surface.

During the months of June to September it was my good fortune to have twenty-four clear nights of good observing on Mars; and here is my reply to some of these questions. The information was obtained by means of a delicate thermocouple radiometer of two kinds of wires, almost as fine as a spider's thread, the junctures of which were flattened into little disks no larger than the period which ends this sentence. These thermocouples were mounted in the eyepiece of a reflecting telescope, and the little round disks of metal, called "receivers," were exposed to the dark and the bright spots on Mars and on small craters of the moon. The heat-rays coming from these spots warmed the little metal disks, giving an indication of the temperature of the surface. As already stated, these receivers were so small that eight separate settings could be made across the image of the disk of Mars, which was only 2 mm (one sixteenth of an inch) in diameter.

The first measurements on stars were made at the Lick Observatory, Mount Hamilton, California, in 1914, and continued at the

Lowell Observatory, Flagstaff, Arizona, in 1921, 1922 and again in 1924, where with the faithful assistance of Professor C. O. Lampland, I have been able to pursue these planetary investigations. We have developed a system of teamwork, which for speed and accuracy in the most trying moments (which are numerous) compares favorably with that of an inanimate, automatic recording device. The scientific world owes a debt of gratitude to this little observatory for its courageous efforts in extending the boundaries of knowledge into the unknown. Looking back over the search of more than eleven years for facilities to try out these thermocouples and its happy culmination in the study of this wonderful planet at this time, it would seem as though all had been in accordance with some prearranged plan. Almost fifty years must elapse before such a favorable opportunity will again occur.

The Martian day is about half an hour longer than our own. Mars has seasons similar to our own, but of double the length; and as summer progressed on the southern hemisphere the thermocouples showed a gradual warming up of the surface, just as we notice a gradual warming of the earth from April to July. But there is a great difference in temperature of the bright and the dark areas on Mars. Even on the equator the noonday temperature of the bright areas, which are probably dry deserts, is but little above freezing. The adjacent dark areas are somewhat warmer, having temperatures of 40° to 60° F. This is just the reverse of terrestrial temperature conditions. While this difference in temperature might arise solely from a difference in absorptivity of the surface, it appears that the dark areas may be at a lower level than the bright areas, which would prevent winds and retain the heat.

Since everybody was interested in Mars on August 22, I shall give some of our measurements. On this date there was no phase on Mars, that is to say, the whole surface facing us was brightly illuminated, and these thermocouples showed that the noonday temperature of the bright regions on the equator was about 5° C. (40° F.), while the adjacent dark regions were perhaps up to 15° C. (60° F.). At the same time the temperature of the east limb or sunrise edge was — 45° C. (— 50° F.) and the sunset edge was 0° C. The temperature of the illuminated polar regions was down to — 70° C. (— 90° F.), which is not much different from our Arctic regions. The temperature of the night side probably drops below — 80° C. These extreme daily temperature variations are no doubt owing to a rare atmosphere; but they also seem to indicate that this atmosphere is more extensive than was heretofore supposed to be present on Mars.

It will no doubt be realized that these temperature values were established under great difficulties, and that it was quite an accomplishment to obtain any reasonably accurate measurements at all on the poles. Hence, the numerical values may not fit the calculated values for different parts of the surface as accurately as we might desire. That is to say, the calculated temperature gradient from the equator to the poles may not be as great as observed; but this will be merely another proof of the presence of an appreciable atmosphere on Mars. However, as already stated, temperatures of -60° to -70° C. occur in our polar regions. Hence, it should not be surprising to find equally low temperatures in the Martian polar regions.

What about life on Mars? That depends upon our viewpoint; whether we think of tropical vegetation or the mosses and lichens which thrive under our Arctic snows and in this latitude during the mild days of January to March, but which shrivel up in summer. These measurements show that for a few hours at noonday on the equator of Mars the surface temperature is not unlike that of New York or Philadelphia on some bright day in March and April. But consider the exceedingly cold nights. The great daily variation in temperature of perhaps 100° C. indicates that the density of the atmosphere is very low. No doubt water exists on Mars, but it is not present in sufficient quantity to form large lakes. What little there is boils at about 45° C. (115° F.) and with a mid-day temperature of half that value, it appears that during the noon hour evaporation of water proceeds rapidly, while during the cold nights much of the water vapor is removed from the atmosphere.

Hence, with noonday temperatures of only 5° C. to 15° C. (40° to 60° F.) even on the hottest spots on the equator, and with exceedingly low temperatures at night, it seems evident that any vegetable or animal life that may exist on Mars must be adapted to withstand these great extremes in temperature and humidity.

Such adaptation seems possible in low forms of living matter, for example, the brilliantly colored lichens which one sees growing on the old lava flows of Arizona, bordering on the Colorado Desert. It is of course well known that the horned toad is accustomed to drought and has about three months of activity during the summer. However, it was a surprise to find that even our common garden toad can adapt himself to dry conditions. I saw one above ground near the observatory on the only really wet night we had in July. But with practically no rain from April to October he had a quiet time of it underground this past summer; and he will have a still quieter time during the coming long winter. Martian life would be equally inactive for the greater part of the year.

It seems evident that while life on Mars appears to be possible, it must be of a kind that can withstand prolonged drought and intense cold. Moreover, with temperatures changing in six hours from freezing half-way up to the boiling point of water, on Mars, evidently the reactions must be rapid. With much of the surface at frigid temperatures, it is reasonable to assume that if vegetable life similar to ours can exist on Mars it must be like the mosses and lichens which can thrive in cool weather. Similarly, animal life must be troglodytic, able to burrow deep and hibernate, or able to withstand the intense cold in a benumbed state, as do, for example, the torpid grasshoppers, wasps and ants one finds on warm days in winter.

Apparently life on the equatorial region of Mars is a continuous process of thawing out and limbering up in the forenoon and a reversal of the process in the afternoon. On the other hand, in the polar regions where the Martian day is from 8 to 12 terrestrial months in length the temperature rise may not be as high as on the equator. But, during the long summer day in the polar regions the temperature variations will not be so extreme and living matter, if present, will not be subjected to such short periodic changes in activity as occur on the equator. From this it appears that in the polar regions of Mars the cycle of reproduction, development and death of the living cell would not be subjected to the hazards that occur on the equator. Similarly, the quiescent period during the prolonged winter would be free from interruptions.

It seems unnecessary to speculate further on this question. The object of this paper is to present our data in a truthful manner. For it is the first time in history that physical measurements have been made which give an indication that the temperature of the surface of Mars rises above the freezing point of water. Prior to our measurements of 1922, and especially those (including of course the Mt. Wilson measurements) of 1924, the general opinion prevailed that the temperature of Mars is far below freezing. On the basis of these new measurements speculation is already rife concerning life on Mars, and the popular press already contains grotesque portrayals of life on this planet. The foregoing is written merely to show some of the limitations of the environment if life exists on Mars.

OBSERVATIONS ON ANIMAL COLORATION

By AUSTIN H. CLARK

UNITED STATES NATIONAL MUSEUM

In any landscape anywhere the most conspicuously colored living objects are first of all the butterflies and next those birds that live in tree or bush tops or habitually frequent the ends of branches.

Among the most brilliant of the butterflies almost invariably the females are much duller than the males. They are also less proficient on the wing and fly less, and for a shorter period, each day. On the under side all butterflies of either sex are dull and cryptically colored, except for certain Riodinidae which rest with their wings outspread.

Among the brilliant birds that live in tree tops or frequent the ends of branches the females are much duller than the males, on the back at least, in nearly all those types that build an open nest. But if they nest in holes, like kingfishers, motmots, rollers, jacamars, wrens, titmice, woodpeckers, toucans or parrots, or in covered nests, like honey creepers, or if they lay their eggs in the nests of other birds, the females are quite or almost quite as brightly colored as the males. In the Lesser Antilles most of the humming-birds and all the orioles are equally brilliant in both sexes, in this respect differing widely from their mainland relatives.

Any hypothesis by which animal coloration is explained must take these facts into consideration, in connection with the correlated fact that most ground-living vertebrates, except for certain lizards that live in open country, and most insects, except for various flower or rock-frequenting flies, bees, wasps and beetles, are dull or cryptically colored.

It is idle to assume that to us male orioles, tanagers, humming-birds, goldfinches, etc., are less conspicuous than their somber-colored mates or that the gorgeous males of *Morphos* are cryptically colored, except when resting.

There seems to be a simple explanation of the coloring of the butterflies, the flower-frequenting insects and the tree-top birds, as well as that of other types which live exposed in open places, especially in semi-desert regions.

The enemies of these are chiefly birds, insectivorous and predaceous types, that hunt by day. As is well known, birds have the most extraordinary vision. Their olfactory sense is poor; their sense of touch is also poor; and though some nocturnal types and a

few others hear with a keenness most remarkable, generally speaking the birds that fly by day are not so quick at catching sounds as are most mammals. Birds, therefore, depend for their existence, for finding food and for protection from their enemies largely on sight alone.

A bird's eye is a wonderfully perfect mechanism. It differs chiefly from a mammal's eye in being built about a lens of shorter focus. The image projected by the lens of a bird's eye therefore lies all in one plane or nearly so, resulting in the equal definition of all the objects in the field of vision. This is quite necessary for an insectivorous bird catching its prey upon the wing or for a predaceous bird. Distance means little to them, detection of their victims everything.

To a predaceous or an insectivorous bird a landscape would consist of a clear-cut patchwork of myriads of fragments of all sorts of colors and of sizes. Each stick and stone and leaf would stand out sharply, no matter how distant it might be.

Against a background of this kind those objects would be least conspicuous which were most boldly colored in the sharpest contrasts, dark and light, more or less regardless of what the colors were. For instance, a brown butterfly broadly marked with red and yellow would appear merely like a quiver, not like a butterfly, for at any given time one or other of its colors would grade into a similar color in the patchwork underneath it. I have noticed this in watching *Heliconii*. Movement of the victim plays the most important part, of course, in its detection. But detection is one thing, capture quite another. Practically all creatures with vividly contrasting colors laid on in a bold pattern, butterflies or other insects, birds and other vertebrates, are restless and nervous in their habits, thus increasing the effectiveness of their coloration.

In the relatively long focus mammal eye and the corresponding lizard eye sharp vision is only possible in a single plane, which is continually shifting back and forth. Beyond this plane the landscape becomes blurred and tends to be reduced to the average color of all its various elements.

Thus the creature least conspicuous to a mammal or a lizard would be one most nearly like the *average color* of the background against which it would ordinarily be seen, and not adorned with sharply contrasting colors, dark and light, matching the *details* of that background, as in the case of birds.

The difference in the sight of birds compared with that of mammals and of reptiles would easily explain the brilliant colors of most butterflies when on the wing contrasted with their cryptic colors when at rest; the brilliant colors of many flower, rock and fence fre-

quenting insects; the bright colors of most male tree-top birds and the dull colors of their mates, unless they lay in holes or covered nests or live in regions like the Lesser Antilles, where there are (or were till introduced by man) no predaceous mammals nor bird-eating reptiles.

It would also easily explain certain anomalies of coloration, such as the conspicuousness of skunks, which have no mammalian enemies but are frequently the prey of great horned owls, and the brilliant coloration of the truly arboreal squirrels of the tropics and of certain tree-top monkeys.

Probably also it explains the assumption by the males of many of our migratory birds in winter of the female plumage. With us the males of tanagers, orioles and similar birds live in the tree tops, continuously exposed to the attacks of hawks but immune from the attacks of mammals and of reptiles, while the females are more or less immobilized at or near the nest or young and are less often seen. In the winter both sexes are the same in habits and are more or less retiring like the females in the north, bringing them within the range of mammals and of reptiles. Some of our birds, like the little redstart, have the same habits in their winter quarters as in their summer home, and in these the same plumage is retained throughout the year.

Practically all male birds when singing in the daytime choose a situation where they are immune from attack by mammals, mostly in tree tops, on rocks or hovering in the air; but evening songsters sing from the interior of trees or thickets where they are protected from the attacks of owls. Some birds, like one of the West Indian mockingbirds (*Mimus gilvus*), sing from the tops of bushes in the daytime, but from the interior at night.

It has never seemed quite plausible to me that sexual selection could have a bearing on the coloration of the birds and butterflies. My belief has always been that the differences existing, which are sometimes very great, would eventually be interpreted in terms of differences in the environment of the sexes.

Recently I obtained what seemed to me to be a clue to what these differences are. Naturally near-sighted, a landscape never appears sharp to me; everything is softened by a lack of definition, and against this blurry background butterflies and birds stand out with great distinctness. I have some glasses which correct this perfectly. With them the background is resolved into an infinity of sharp patches of all shapes and sizes and of widely different colors. I notice that against this background it is very difficult to follow the courses of butterflies, especially the more conspicuous ones, like red or white admirals. Those easily seen, like the whites and yel-

lows and the satyrines, are very rapid or irregular fliers, practically impossible for any bird to catch, or such types as *Terias lisa* and *T. nicippe*, which are protected by their resemblance to more powerful pierines.

A curious feature connected with animal coloration is that in all groups the most splendid iridescence occurs in the American tropics, along with the greatest development and splendor of both groups of fireflies and the extraordinary development of the prehensile tail in many groups of mammals, in contrast to the gliding flight of many mammals and reptiles in the oriental tropics.

Mr. Thayer has ably shown that iridescence is a most effective type of concealing coloration. I have noticed this myself in watching Morphos, the most brilliant of all butterflies.

In the South American forests animal life for the most part is restricted to the tree tops, which typically form almost an unbroken canopy. The maximum development of tree-top coloring should therefore be expected. Furthermore, in traveling through a more or less continuous leafy canopy gliding flight is of no advantage, as it is in the more open forests of the east; so far as possible the animals must endeavor to remain always within the protection of the canopy, and to this end the prehensile tail is a great asset. Underneath this canopy the conditions favorable to the existence of the fireflies and unfavorable for the existence of their enemies are developed to the maximum degree.

For the most part brilliant iridescence is confined to tropical types, both in birds and butterflies. If northern or southern types are iridescent the iridescent areas are mostly red, as in rufous and ruby-throated humming-birds and copper butterflies. But in the tropics iridescent birds and butterflies are not confined to the hot lowlands. There are many in high mountain regions where the temperature is low.

In South America I was surprised to see how difficult it is to follow the great blue Morphos in their flight; the change from blue to purple and to green was most confusing. But in Massachusetts I was equally surprised to find that dead Morphos were always great blue butterflies, while the little coppers are as confusing in their flight as are the Morphos in the tropics.

The only explanation that occurs to me is that in the tropics, where the sun is directly overhead and the iridescent butterflies fly only in the middle of the day, the direct rays give the maximum effect to iridescent colors, while in the high latitudes the greater diffraction of the light destroys the value of such iridescence, especially in the shorter wave lengths.

COOPERATION AMONG SCIENTIFIC MEN

By Dr. WALTER P. TAYLOR

UNITED STATES DEPARTMENT OF AGRICULTURE

I. Science is a benefactor of humanity, but, unfortunately, so far, the world does not "stir itself to make it possible for its benefactors to live and work." This makes necessary organized voluntary cooperation among intellectual workers.

Science has done much to better the lot of mankind. It has helped to eliminate disease, superstition and ignorance. Its beneficent services underlie and maintain the complicated structure of modern civilized society. It has remained for science, through innumerable contributions to production, transportation and communication, to make of the world a unit, such that democracy and world brotherhood, formerly the dreams of far-sighted men of prophetic insight, have for the first time in history become actual possibilities. Scientific men and intellectual workers generally, to whom these advances are due, should be recognized as among the most valued servants of society, and, as a matter of course, provided with the economic essentials to good work. Unfortunately, however, the public has no clear appreciation of the fundamentally important rôle played by the intellectual worker, and, as a consequence, makes very little effort properly to support his work.

(1) The intellectual worker should realize that he, himself, as well as the public, has a definite responsibility for the conditions under which he works.

The advance of the intellectual worker has been slow and painful. No longer a slave, as in the days of imperial Rome, he has at least attained the status of a quasi-independent clerk to property or the state, all too often, it must be confessed, hired and fired at the will of an autocratic individual or governing board according to the commodity law of supply and demand. Even under these hampering conditions he has played a fundamentally important part in building the modern world.

It is clear that civilization can not go forward, can not even be maintained, without the contribution of the intellectual worker; it is equally obvious that the intellectual worker can not do his best work unless he himself has won economic and intellectual freedom. The responsibility for providing proper surroundings of economic and intellectual freedom for the brain worker rests on at least two groups, namely, the public and the intellectual worker himself, and I am inclined to think that the heavier responsibility rests upon the

latter. For the worker knows, or ought to know, the conditions he must have for effective operations, while the public for the most part does not.

No longer should the intellectual worker stand and wait for the public to recognize the value of his work and to provide the essentials for it. He has played this waiting game in this country for so, these many years, with the result that science has not progressed as it should, and education has been far from satisfactory. An English scientist recently made the very pertinent comment (*Nature*, December 22, 1923, p. 912) that the proportion of Americans eminent in science is disappointingly small when the resources of the country are taken into account, and we are bound to admit that his comment has some foundation. The public, unfortunately, is occupied with many other things than science; the stock market, property rights, the heavyweight championship, the national defense, the income tax, the all-engrossing daily round of duties. Few people even glimpse the significance of science in civilization. For this it seems certain that the scientist is partly, perhaps largely, responsible. Science has made civilization possible. Is it not time the scientific worker wrote his declaration of independence from hampering economic conditions? Does it accord with the essential worth of his work that he should be compelled to play the courtier to the politician or to the Napoleon of industry? Is it well for him to continue to be a dependent, subsisting as best he may on the uncertain bounty of a philanthropic capitalism? (MacDonald, "The Intellectual Worker and his Work," 1924, p. 319). It seems clear that the intellectual worker ought to stand on his own feet, tell the public what is needed, and inspire such pressure of popular opinion as is necessary to get it. This implies the possession on the part of the scientist of ability to enlist the attention of the public, and to insure some sort of equality of bargaining power between himself and his employer. There are three roads to power; the road of the genius, whose power is a gift from the gods; the road of the plutocrat, whose power is derived from the money he has made or taken; and the road of the cooperator, whose power comes from the agreement of many minds on certain fundamental issues. The road to be taken by the intellectual worker is plain. On the average he certainly is not a genius; nor is he a money maker; but he has demonstrated that when he desires to do so he can become a cooperator.

The problems involved in the insuring of proper working conditions among scientific men are of far more than individual significance. The intellectual worker should be the first to appreciate the fact that he is bound up in a web with all his colleagues. On the professional and scientific sides this has long been recognized,

and it is no less true in the social and economic spheres. Whenever the status of any group of intellectual workers, whether of pay or tenure or freedom to study or teach, is impaired, the status of all is so much less secure; and, correspondingly, wherever the condition of any group of intellectual workers is improved, the situation is just so much better for all the rest. It seems clear that these principles apply to intellectual and scientific-technical workers quite generally, irrespective of the accident of their employment by university, museum, academy, private scientific foundation, or state or federal government. They might well be made the basis for increased sympathy, loyalty, and helpfulness, in short, for a vastly augmented cooperation, among these workers. It appears that only through some such proper cooperation can the scientific worker maintain his own respect and make his best contribution to world progress.

(2) One essential to effective cooperation among scientific men is the definite abandonment of ultra-individualism, and its replacement by group loyalty, sympathy and mutual helpfulness.

The work of the scientist has always been on a lofty ethical basis, though founded almost altogether on an individualistic philosophy. The ethics of cooperation are higher and considerably more difficult of successful attainment than the ethics of individualism, but they promise far more for the future.

Close attention to one's specialty with little thought of the other fellow is the line of least resistance for the intellectual worker. Ultra-individualism, like ultra-nationalism, once the "flame upon the altar," is now likely to be "a devastating scourge."

On the other hand, compulsory cooperation, effected through a disciplinary organization of scientific work and workers such as Elihu Root appeared to have in mind a few years ago in connection with the organization of the National Research Council, could not possibly be effective or successful in the long run. Such pseudo-cooperation would, in my opinion, work greater havoc than a rampant individualism. In order to be helpful cooperation must come from within the ranks, and must be a very liberal affair, allowing for the widest differences of opinion and interpretation, and acting rather as a stimulus than as a damper on individual initiative.

In commenting on certain policies of farmers' cooperatives, a writer in Wallace's *Farmer* (February 8, 1924) calls attention to the necessity for remembering that these practices are means rather than ends. "The end we are striving for," he says, "and that cooperative organization seems most likely to bring about, is the creation of a rural civilization that will offer the greatest opportunities for the freest development of the human spirit." Similarly,

what intellectual workers are striving for, and what voluntary organized cooperation seems most likely to bring about, is the creation of an educational atmosphere that will offer the greatest opportunities for the freest development of the human spirit.

When I refer to group loyalty, I do not necessarily limit the concept to one particular group; but it ought to be realized that the pervasiveness and purity of group loyalty, sympathy and mutual aid among intellectual workers may be taken as an earnest of the possibility of their expanding these great conceptions to embrace all humanity.

(3) Definite organization for the economic as well as the scientific advancement of intellectual workers will naturally follow the development among them of the cooperative spirit.

Cattell (THE SCIENTIFIC MONTHLY, Vol. 14, 1922, p. 568) has called attention to the fact that scarcely any group has been so backward in democratic organization as men of science; and there is no other in which conditions make the right kind of organization more necessary. As already suggested, the securing of the minimum rights and guarantees for effective service of the public will require some acquisition of power. Whether or not it is widely realized or intended, it is true, nevertheless, that the intellectual workers at present are often the defenseless victims of organized power of other groups, political, industrial or religious. As Ames (*Science*, October 25, 1918, p. 410) has said, the scientific men of America have suffered greatly at the hands of the people. Handicaps of the sort implied are inevitably reflected in less effective research and education. After all, the public is really the chief party at interest when the adequate maintenance of scientific work is under discussion; for on the maintenance of such work the public welfare absolutely depends.

(4) The practicability and desirability of the organized cooperation of intellectual workers is demonstrated by actual accomplishments in many places, more especially in certain European countries and in England.

The organization of intellectual workers has made notable progress in recent years, particularly in Europe. In France, some three or four years ago, M. Henri de Jouvenel, one of the French delegates to the League of Nations, succeeded in establishing the Confédération des Travailleurs Intellectuels, which now comprises no less than 83 societies with 180,000 members, and which represents practically every intellectual occupation in France (MacDonald, *op. cit.*, p. 290). Similar associations have been formed in eight other countries (*British Medical Journal*, quoted in *Science*, May 18, 1923). A meeting of representatives of these associations was

recently held at the Sorbonne, with the countenance of the French government and under the honorary presidency of M. Leon Bourgeois, one of the most universally respected of French statesmen. It was attended by observers from nine other countries. After a brief discussion it was decided to found a *Confédération Internationale des Travailleurs Intellectuals*.

Ultimately, it is to be hoped that the organization of scientific workers in this country would affiliate with other intellectual workers in such societies as the American Medical Association, the American Institute of Chemists, the American Association of Engineers, and the numerous other organizations of brain workers, to form an American Federation of Intellectual Workers. American scientific men would then be ready to take their place, whenever they wished to do so, in the international body.

(5) Warlike economic policies will not ordinarily appeal to the intellectual worker.

While it is perfectly proper that any institution dominated by arrogant autocrats, who sacrifice academic freedom to some form of partisan expediency (religious, political or industrial) should be isolated by force of an aroused and indignant professional public opinion, such an association of intellectual workers as that proposed would seldom find it necessary to resort to economic violence, especially if it was generously and loyally supported by large numbers of scientific men. The organized power of this group, like that of the physician and the engineer, would for the most part be exerted in investigating the economic problems of the scientific worker, in educating the scientist and the public to pertinent facts and needs, in peaceful cooperative effort to influence opinion or legislation in the way it should go, and in widespread and pitiless publicity. These tactics, coupled with a refusal on the part of eligible scientists to accept positions from which the prior occupant was known to have been unfairly dismissed, would undoubtedly be effective in most cases. Probably no group in society recognizes more clearly than the intellectual workers the superior effectiveness in the long run of peaceful and evolutionary economic policies as compared with more violent measures.

II. Organized cooperation will make science more efficient.

(1) Experience in the worlds of business, labor and agriculture demonstrates the economic advantages of organized cooperation.

There are few who would deny that organizations of business men, manual workers and farmers have been economically advantageous to the groups represented. It is increasingly evident, also, that proper organization affords a medium for the maintenance of higher standards of service to society on the part of these groups, respectively.

(2) Poor pay, insecure tenure and dependency, which tend to lower efficiency, would be gradually eliminated by organized co-operation.

An early result of any organized cooperation worth the name would be the securing for intellectual workers of improved status of compensation and tenure. As a writer in *Science Progress* stated some years ago (quoted in *Science*, May 4, 1917, p. 433) perhaps the worst form of scientific snobbery is the pretense that the man of science is above cash in any form. As in other fields so in science ". . . the proper and honest procedure is to pay for the work done . . ." As Dawson has said (*Science*, June 7, 1918, p. 550), the undowered muse is a proposition not only personally inconvenient, but also incompatible with the highest efficiency. Is it fair, in a democracy, that research on the subject of one's choice should be a luxury attainable only by those who have independent incomes, or who are willing to give up the prospects of a family? (Giesy, *Science*, January 11, 1924, p. 46).

The pay-scale for intellectual workers would not need to be commensurate with services rendered. As Cattell has said (THE SCIENTIFIC MONTHLY, Vol. 14, 1922, p. 569), full payment would be three fourths of the wealth produced annually by industrial nations. Underpayment may help to insure purity of motive and be beneficial if it is not carried too far. But is it not reasonable to insist that the compensation of scientists be put on a basis such that each worker can do his chosen work under reasonably effective conditions? Certainly Preston Slosson's suggested schedule of pay for professors (*Science*, August 24, 1923, pp. 140-142) does not provide for over-compensation of the competent.

The intellectual worker is, of course, supposed to take out shortcomings in his salary in honor and dignity. But, as MacDonald well says (*op. cit.*, pp. 255-256), "The supposititious dignity which popularly attaches to certain intellectual occupations has long since ceased to be anything more than a cloak for discrimination and exploitation, an excuse for systematic underpayment, and a consequent wholesale lowering of living standards. It can never be undignified to assert and enforce one's just claims to recognition and fair treatment."

Of first concern to the maintenance of adequate professional standards among intellectual workers is the question of tenure. The right to his job of the experienced scientific-technical worker who has demonstrated his capacity must of necessity be secure if he is to do his best work. Dismissal should only be possible on grounds of proved immorality or gross incompetency, and only after the careful consideration of each case by a jury composed not only of

administrative officers, but of professional colleagues, some of whom should be members of other institutions than the one directly concerned. Advance notice of the intended action, with charges preferred in writing, and opportunity to make adequate presentation of his side of the case, should be the irreducible minimum of protection for any professional worker. It is coming to be more widely recognized that any other course of action is bound to result in impaired morale among the intellectual workers not only in the institution affected but elsewhere, and to be followed sooner or later by a train of untoward and unfortunate circumstances involving loss, on the part of the workers, of academic freedom, peace of mind, respect for the offending administrative officials and self-respect. The ultimate effects of such action are likely to prove even more disastrous to the administrative officials involved. The greatest losses of all, however, are borne by the public, through the inevitable decline in standards and impairment of efficiency of its scientific servants. There is probably no current question affecting the status of intellectual workers more significant than this one of tenure, and I venture to say it will never be satisfactorily answered until the scientific-technical group succeeds in establishing some far more effective scheme of organized cooperation than any that has been achieved heretofore.

In this connection professional ethics should be understood to require a careful investigation on the part of every candidate for a position of the circumstances surrounding the departure of his predecessor; and the acceptance of a position by a candidate, when his predecessor is known to have been unfairly dismissed, should be recognized as constituting a serious breach of professional honor.

(3) Organized cooperation would promote that freedom of teaching and research which is essential to good work.

As President Hopkins, of Dartmouth, said recently, "The minute that education becomes something besides sincere and open-minded search for truth, it has become a pernicious and demoralizing influence rather than an aid to society and an improver of civilization." It is the veriest truism that the maintenance of civil and academic liberty is essential to the accomplishment of effective research and education. Surely it needs not to be said that academic freedom is only the freedom to try to see the world as it is and to try to tell others what is observed and what conclusions seem to be indicated. It is obvious that only through the obtaining and maintenance of freedom of this sort can we hope to maintain our civilization or to win a higher one. The trials and tribulations of the workers in economics, politics, sociology, philosophy, Bible study and biology in some institutions should be recognized as full

of concern to all intellectual workers. Cattell's assertion in his commencement address to the graduating class of the University of Arizona, 1924, that he knows of no socialists who are members of departments of political science in any American university is not without significance. A proper cooperation between intellectual workers implies determined opposition to all forces whatsoever that threaten academic freedom, and unvarying support to individuals or groups who help maintain it. Not only moral, but also financial encouragement, where necessary, should be given, by the rest of us, to any of our colleagues who happen to be on the firing line in this age-long fight.

In suggesting cooperation in organization as a protection for professional prestige, there is no necessary idea of friction with administrative officials. Only those administrative officers whose policies ought to be opposed would ever run afoul of such an organization; and such an association would be a continuous source of power and support to those progressive administrators who recognize the mutuality of obligation between an institution and its personnel, and who stand sturdily for the advancement of intellectual workers and their work.

(4) Scientific standards would be raised.

The doctors and lawyers very properly give close attention to standards of admission to their ranks, thus insuring protection to themselves and the public from the inefficient and the poorly prepared. Similar attention to standards on the part of other intellectual workers may be relied on to bring about great improvements. Certainly standards should be high enough to insure that only those would be admitted to the profession who could give adequate service. This would prevent an over-supply of cheap intellectual labor, with the concomitant lamentable competition for underpaid positions. Fewer workers in all these lines, better trained and better paid, would be best not only for the workers and their families but for the public as well.

III. More effective scientific and intellectual service is greatly needed by mankind.

(1) To promote the health, welfare and happiness of the people.

Howard (*Science*, December 30, 1921, pp. 650-651) and others have called attention to the fact that the firing line in the most serious struggle for existence is that between man and insects and still lower creatures. Authorities of the Biological Survey of the United States Department of Agriculture estimate that the western farmer pays tribute of \$300,000,000 annually to rodent pests alone. The problems of coping with animal and plant pests, including disease producing organisms, are vital matters to our species.

Of equal importance is the group of questions associated with the maintenance for all of a fair standard of living. These include the problems of (1) Population, (2) Conservation (of soil, mineral resources, forests and valuable plants, beneficial wild life), (3) Maintenance of scientific research and invention (especially in respect to food, shelter, health, power, transportation and communication), and (4) Sociology and economics (including war, education, distribution of wealth and commodities, poverty, crime). It is obvious that the solution of problems in all these groups will fall, in large part, on intellectual workers. Take the war against the insects, for example. Howard's conclusion is that in order to accomplish the very necessary task of bringing the great group of insects under control the services will be demanded of thousands of skilled biologists. Recurring epidemics of foot-and-mouth disease in this country emphasize the fact that in serious emergencies of this kind the people of state and nation can only turn to the scientific-technical group for help. The trouble is that our information is insufficient because of inadequate research work; and there are not enough well-trained scientists, the paradox being that the public takes very poor care of those now in the field. Cattell once suggested (*THE SCIENTIFIC MONTHLY*, Vol. 14, 1922, p. 570) that in a nation whose maximum military establishment was placed at 100,000 the number of scientists engaged in research should be made a minimum of 100,000. Efficient defenders of mankind from his insidious insect, rodent and microbe enemies can be provided by the universities. But the public must be educated to see the necessity for something more than starvation wages and uncertain tenure for these defenders. It will not do for educational institutions to go on turning out biologists and others if the end result is to be merely the swelling of the ranks of cheap intellectual labor. The scientific-technical workers must cooperate to make the public see this.

(2) To secure a more equitable distribution of the results of scientific discoveries.

No economic system which permits the colossal rewards of modern industry which the scientist has made possible to go almost exclusively to the few while the many lack the necessities of life can ever receive the seal of his approval. The ignorance and greed so obvious in the organization of modern society threaten the integrity not only of scientific work, but of civilization itself. Often they are linked with special privilege, seized and held by the powerful and the unscrupulous. The intellectual workers as a cooperating group should be in the forefront of efforts to eliminate them.

(3) To prevent war.

The use of the products of science in war is a monstrous perversion of the purpose of science. Jordan ("Footnotes to Evolution," 1913, p. 374) has well said that the ultimate end of science is the regulation of human conduct. Seeing true means thinking right. Right thinking means right action. To bring about right action is the end of science. Greater precision of thought and action makes higher civilization possible. The statement that ". . . science, mental endowments and education are no specifics against a wicked heart" (Withrow, *Science*, June 15, 1917, p. 596) is unfortunately too true, and it is a reproach to every intellectual worker.

Of recent years and especially since the world war, there has been an increasing protest against the use of science to develop improved methods of killing one's neighbors. A writer in *Nature* (December 22, 1923, pp. 889-891) recently quoted from Galsworthy as follows: "We have made by our science a monster which will devour us yet, unless by exchanging international thought we can create a general opinion against the new powers of destruction so strong and so unanimous that no nation will care to face the force which underlies it." Mr. Galsworthy, it seems, believes that more pains should be taken to apply the methods of science to human problems, to face the facts honestly and fearlessly, and to base just conclusions upon them.

In this whole matter the scientific-technical man has a prime responsibility, and it is gratifying to note that he is recognizing it. Witness the following significant incident involving an eminent British university professor. Some years ago, just after the war, the British War Office invited a number of scientists to become members of a committee to develop to the fullest extent "both the offensive and defensive aspects of chemical warfare." One of those invited, Dr. Frederick Soddy, professor of chemistry at Oxford, refused indignantly, as he ". . . felt that universities and scientific men stood for something higher than had yet found expression and representation in governments, particularly in their international relations" (*The New Republic*, November 24, 1920, p. 307). Professor Leonard Barstow, F.R.S., in his presidential address before the National Union of Scientific Workers in 1921, also spoke in opposition to the suggestion of the War Office that university professors should be given charge of secret laboratories working on the preparation of life-destroying chemicals. "None of us," he said, "can regard without horror the possibility of the destruction of our wives and children by murderous inventions, and we feel that science may be so used by the governments of the world as to effectively wipe out mankind. Aeroplanes carrying lethal gases can not be regarded as signs of progress, whereas aeroplanes which can

safely carry mails and merchandise or facilitate the rapid provision of succor in dire calamities are things to be desired" (MacDonald, *op. cit.*, pp. 226-227).

In commenting on the position of the scientist in the war against war, a recent writer (Glaser, *The World To-morrow*, February, 1924, p. 46) has suggested that the scientist might well formulate his intent to refuse in times of peace to work on bombs, poison gas and projectiles in something akin to the ancient oath of Hippocrates, which even to-day adds dignity to the medical profession; and he goes on to suggest that if the scientist were to ally himself with others of like mind in his profession and the medical and scientific group as a whole were to link its fortunes with some international group of labor large enough to strike effectively and at the same time keep from starvation and out of jail, there is little doubt that science could prevent the prostitutions and desecrations which to-day make it as much an instrument of harm as good. As we recall some of the results of the last war, five million war widows, nine million war orphans, ten million refugees, twenty-six million lives lost, three hundred thirty-seven billions of dollars spent (Page, "War, Its Causes, Consequences, and Cure," special edition, 1923), we can begin to realize that we are fighting for our lives with the war system. On the issue of this struggle will depend not only the possibility of maintaining a fair standard of living, but the very existence of civilization. It is science which makes war so damnably efficient; why should not scientists exert the might of their cooperative influence against war, and in behalf of a great constructive peace program in its place?

(4) To strengthen democracy.

Science having made democracy something more than a dream of the prophets, scientific men and intellectual workers have a prime responsibility to help make it workable and effective. The results of science must be taken to the people and the distribution of these results must be put on a fair basis. All science, both pure and applied, should be for use by mankind. As J. C. Merriam once wrote (*Science*, November 19, 1920, p. 476), "Research should lead to construction and is not complete unless the results are available for general use." In theory most of us agree with this principle, but in practice we fall short of realizing it. Over-absorption in a specialty is not only one of the principal reasons why the individual scientist is exploited on every hand, but it also lessens his contacts with public problems for the proper solution of which his work is essential. As Branner has well said (*Science*, May 4, 1917, p. 418), "Our presidents, governors, judges, mayors and others in public life need the services of men of science." Geddes (*California*

Alumni Monthly, 1922) has called attention to the fact that while every country has had a great number of lawyers in its government, one must seek far to find the country in which the best medical minds, the best engineering minds, the best scientific minds, are taking part in the national government, directly as responsible legislators and cabinet officers. The matter of health, he says, is purely a question of good government. The same may almost be said of questions of economic adequacy and of such problems as war, poverty and crime. "We will never," says Geddes, "get really satisfactory governing bodies until we have got the best thought in each of the great scientific lines of thought represented effectively in them. We must arouse the scientific and well-instructed men out of their absorption in teaching, in the work of a profession, and interest them in government." These remarks of Geddes imply a very lofty and difficult conception of the duty of the intellectual worker, and demand from him a willingness to cooperate with the community which I fear few of us possess at present. It is perfectly certain, however, that in addition to our very proper present-day ideals of whole-hearted devotion to our specialties we must assume a new ideal of professional and community cooperation. I suspect our hardest task will be, not in awakening the public to the need for more liberal support of scientific work, but in educating ourselves to work and strive together, to be cooperators instead of competitors.

Greatly needed just now is a new declaration of confidence in democracy. There seems to be a temporary widespread dissatisfaction with the way democracy has worked out, not only in the state, but in the church, in industry, and even in education. This has paved the way for the reascendancy of dictators, in many provinces of life and in many countries. Millikan (*Science*, October 19, 1923, p. 294) asserts that the supreme question which the present generation faces is "Can we make democracy work?" Is it not desirable that the scientific investigator assume the responsibility for making democracy work in his own sphere; for insisting on a more democratic basis in his institution, and for associating democratically with his fellows in a consideration of common problems? Why should we not learn to take "a more rational, a more objective, a more scientific attitude" toward the conditions under which intellectual work is done, as they affect the kind, quality and amount of the product?

Democracy is admittedly difficult, with its program of cooperation, brotherhood and mutual aid, and with its utterly impractical tendency to regard the individual as an end in himself. But do we wish to reinaugurate an era of autocracy, with its intent to deliver

the world to the strong, the ruthless and the egotistic, the kaisers in government, industry and education? The answer is plain as soon as we state the question.

The alternative to autocracy is organized democratic cooperation. We shall look forward to the time when, through this kind of working together, the intellectual workers shall have attained to the full stature of manhood, and when, self-respecting and respected, they shall have won that economic liberty which must precede intellectual liberty, and shall have demonstrated to the satisfaction of all that "science and its applications should be a chief concern of a democratic nation that would preserve its democracy and advance the freedom and the welfare of its people" (Cattell, *THE SCIENTIFIC MONTHLY*, Vol. 14, 1922, p. 577).

ON THE TRAIL OF THE VANISHING SPRUCE

By D. S. JEFFERS

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AND

C. F. KORSTIAN

APPALACHIAN FOREST EXPERIMENT STATION

THE romantic story of the "lost tribe" has invariably caught our fancy, in whatever form it has appeared. There is a wistful appeal in the picture of an isolated community, preserving in some forgotten corner of the world the manners and customs of a far-distant homeland. The original lost tribes of Israel or the fabled lost "Atlantis," the realm of Prester John, the imagined but never discovered remnant of the Aztecs in Peru, all these and many others have beguiled us, down to the survival of seventeenth-century England that is found to-day in the mountains of Kentucky and Arkansas. All unknown to many, we have in this country another lost tribe, a vanishing race, whose romantic history antedates even that of Israel or the lost Atlantis, and which has remained through the centuries, isolated in an alien land, and yet clinging persistently to the characteristics of its own kind hundreds of miles and thousands of years away. The "lost tribe" in this instance is not, however, a kind of men, but a species of tree, or rather two related species, red spruce and Fraser fir, direct descendants of the Canadian spruce and balsam.

When northern America awoke from its long sleep under the great blanket of ice, animals found new lairs and plants new habitats. Marked changes in climate had been wrought by the southward movement of the glaciers. There had been a slow southward procession of boreal climatic conditions, which irresistibly set to migrating all species which were able to migrate. Not animals alone, but vegetation as well, had spread southward in advance of the great glacier. Even trees had migrated with the rest, the northern species finding new sites as the warmth-loving southern species were frost-killed and driven forth.

In this manner the red spruce came from its home in the north and, well in advance of the last reach of the ice sheet, established itself in the region now covered by the Central Atlantic states. The migration was not confined to spruce alone, for birch, beech, maple and other northern species traveled in the same caravan. All doubtless became well established in this part of the country, until



AMES FORESTERS

"hiking over the hills and far away" to the native haunts of the red spruce.

the glacial period came to an end. Then came disaster. In the increasing warmth, the forests of the south must have waged a relentless and successful warfare against their hapless northern rivals. Only those trees and plants could escape that could climb above the altitude limit of the prolific southern vegetation. This the spruce, among others, succeeded in doing, and became accordingly confined in this region to the highest summits and loftiest ridges, where, in the Southern Appalachians, it has persisted all these centuries and is found to-day.

The range of red spruce is thus decidedly limited, because of the relatively small area that is high enough to reach the bracing coolness and the plenitude of moisture spruce demands. The Southern Appalachians are themselves the remains of a plateau, once higher than the highest of the peaks remaining (6,711 feet). Composed of much soft rock, which weathered away, exposing the harder surfaces to a slower erosion, this plateau gradually lost all identity as such and took the form of the present mountain range, more than forty of whose peaks rise 6,000 feet and over. At this elevation the temperature is comparable to that of southern New England and the sub-alpine climate of the Rocky Mountains. Because of the greater elevation, however, the atmosphere is much more moist and the rainfall heavier. Here the red spruce has kept its hold, with its more wintry range-mate, Fraser fir. The latter, beginning in the uppermost part of the spruce zone, grows in almost pure stands of small extent, and is the counterpart of the balsam fir of eastern Canada.



WHAT KIND OF TIMBER WILL THE NEXT GENERATION YIELD?

This crew is running a regeneration survey to determine what the chances are.

Other compatriots of the spruce have also found lodgment, and in the lower part of the spruce belt the hardwoods and hemlock of the north mingle with the hardier species. Here all the vegetation is suggestive of Northern New England and Canada, while the true soil under the trees is covered by a spongy layer of plant remains known as upland peat, sometimes more than a foot in thickness, and frequently as acid as the peat of many of the Coastal Plain swamps.

Successful in its warfare with nature, the spruce in recent years has found certain man-made circumstances too powerful for it. War between nations across the ocean has touched these spruce forests and decimated them, for modern warfare calls for aeroplanes and aeroplanes demand spruce and fir of the splendid quality so often found in these Appalachian stands. War and a growing population in the cities call also for more newspapers, and newsprint takes a heavy toll of spruce, wherever it is available. For these reasons a large portion of these spruce lands has been logged over, involving a great loss in streamflow protection and scenic value, and contributing but an insignificant amount to the nation's wood supply. What centuries of continuously hostile climatic conditions could not do to dislodge this valuable forest remnant, man has been accomplishing in a short span of years. The Appalachian



WHAT KIND OF TIMBER WILL THE NEXT GENERATION YIELD?

This is the kind which has been cut, fine red spruce and Fraser fir.

spruce is vanishing and may well become extinct if man does not repair the destructive work he has started there.

Details of the logging operations that are clearing off these forests will make the situation clearer.



YELLOW BIRCH, A NORTHERN HARDWOOD,
near the upper limit of the Southern Appalachian spruce type.

A large portion of this region has been logged over, the spruce lands yielding a cut averaging from 18,000 to 30,000 feet to the acre board measure. In these operations the overhead skidder has been used to some extent to get out the material that lay above the logging railroads and at the heads of the flumes. On the steeper slopes dry slides are sometimes used and frequently the pulp-wood bolts are rolled down the steep mountain sides, a process locally known as "ball-hooting." Frequently, when the saw-timber has been logged from an area, the latter is "wooded," which means, in local parlance, that it is again cut over, this time for pulpwood. This second cutting removes trees down to about six inches in diameter. The slash left after logging is a fire trap, and the scarlet scourge—the ever-present enemy of young spruce—has taken its toll of the remaining small trees, leaving them as gray sentinels to mark the passing of the present generation. Where logs have been skidded downhill by horses and dragged uphill by the steam skidder, rain has within a year started to "gully" the mountain side.

What kind of timber, if any, can be cut from the next generation on such desolated areas? That is the important question which has confronted foresters and, to some extent, timberland owners with reference to the spruce-fir type. The forestry problems of this type are of a very difficult nature, and have called for some of the

initial work of the Appalachian Forest Experiment Station, which the federal government has established in this region.

The Forest Experiment Station, however, is not alone in its interest in these tracts, and only this last summer was fortunately



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SHORT AND SIMPLE ANNALS OF THE SPRUCE

1917—virgin timber; 1918—cut-over; 1920—burned; 1922—fire cherry and blackberry thicket.



THE MOUNTAIN SIDE

commencing to gully one year after logging (horse-logging, in this instance).

able to effect an alliance with other students of the Appalachian spruce problem, to their mutual advantage, and incidentally to the advantage as well of the "lost tribe." The opportunity was afforded through a field expedition to these woodlands from the Iowa State Agricultural College, at Ames, Iowa, consisting of sixteen embryo foresters and their two instructors. Engaged on a three months' expedition which included detailed tree observation and first-hand study of logging, mapping, surveying and timber estimating, the Iowa students were hungry for practical forestry of any sort. Sawmills, planing mills, paper pulp mills, acid extract plants, tanneries and veneer plants were to be visited in the course of the summer, but for a preliminary working-out they made their camp in the woods. Thus it was that they found themselves not many miles from a field party of four men from the Appalachian Forest Experiment Station who had already begun work on a so-called "regeneration survey" of the spruce cut-over lands, gathering facts and figures of the new growth actually appearing on these acres.

There is an affinity between foresters which a few miles of rough going can not dampen; so with packs on their backs the Ames foresters "hiked" over the hills to the native haunts of the red

spruce and the Fraser fir, joining the Appalachian Station field party in a several days' search for the elusive spruce and fir seedlings on cut-over lands.

The unexpected assistance made a 100 per cent. survey possible to the Experiment Station foresters, and was a valuable experience to the college men. Previous plans for the survey were immediately adapted to make the most of the opportunity. Strips 20 feet wide were run across the cut-over areas, literally gridironing them. All sorts of conditions, all slopes and all exposures were examined. The students, in crews of three, under the immediate guidance of a trained field assistant, tallied all the young trees down to the smallest year-old spruce seedling, recording also the old stumps, and gathering information on various general phases. To make certain that every spruce and fir seedling, no matter how small, was found, it was necessary to examine carefully every square foot of the strip.

The result of this combined work, as well as that of the Experiment Station men after the young students had done their bit and gone on to other fields of experience, is a collection of figures and computations, dry-as-dust to every one but the forester perhaps, but of considerable significance as the latest, though it is to be hoped not the final, chapter in the romantic episode begun by the great glacier some six or seven hundred centuries ago. Whether we shall write "Finis" to this tale within the next half century,



AT THE INTERSECTION OF TWO SKIDDER LINES.

Nature may save the situation unless fires come; but the odds favor the fires.



THE SPRUCE VANISHES IN THE PAPER AMERICA BURNS.
Forestry students measuring spruce and fir pulpwood before it is shipped to
the pulp mill.



WHAT THE GOVERNMENT AND ALL FORESTERS DESIRE—
splendid 25-30-year old stand of red spruce and Fraser fir reproduction on
cut-over land.



AFTER MAN AND HIS MACHINE HAVE LEFT,
the "Scarlet Scourge" takes its toll. Cut-over spruce land burned in 1921.

or whether we shall continue it indefinitely and to our very obvious profit, depends upon the immediate action taken as a result of these observations. To round out the present account, a summary of all these findings may not be amiss.

On the cut-over spruce lands where fire has not burned, the young trees are coming up satisfactorily. These trees were seedlings before the cutting was made. New seedlings, dating since the cutting, have not yet appeared save on the older tracts. Altogether there is enough of this young growth to continue to hold these lands for spruce, if fire does not intervene; but there is not enough to result in fully-stocked stands in this tree generation.

Where fire has come, even though only once, the cut-over lands are in a hopeless condition, so far as spruce is concerned. Blackberry and raspberry briars overrun these acres, to be succeeded by fire cherry and yellow birch, which according to count run several thousand an acre and in this region are of no commercial importance.

Only occasionally on these burned areas are live young spruce found, and then around springs and seeps, or along streams, where the small advance growth of seedlings and saplings escaped, evidently because the fire was halted or because it was unable to burn the upper layer of soil where seeds were stored.

All told, it is evident that the amount of new growth is entirely inadequate for a future stand of softwoods on by far the greater



AMID THE GRAY SKELETONS OF THE SPRUCE,
jungles of briers, fire cherry and yellow birch grow up.

number of these spruce burns. If new stands of spruce and fir are to be available within a reasonable time, the slow and expensive method of planting must be adopted.

Most obvious and most important of all is the fact that adequate fire protection must be put in force on this cut-over land; otherwise what is true of these spruce burns will soon be duplicated throughout the length and breadth of the Southern Appalachians. In that event, the cool mountain streams flowing from hidden springs among the spruce-covered rocks, and inviting alike the hydroelectric engineer and the profitable tourist, will cease to flow. Down gullied, barren mountain sides spring torrents will rush, destructive and profitless to any. Throughout the summer no even flow will be preserved; no wheels will be turned; no hiking pleasure-seeker will find here the refreshing invitation that brings him to such regions. With the vanishing spruce, the good that it has done to the mountain communities will vanish with it. Though strayed far from home and though driven to the heights to maintain itself at all, the Appalachian spruce has paid its way these many years, has made itself a good citizen and friend to man. Now, in its direst extremity, turn about is fair play: the perpetuation of the spruce type in the Appalachians is the duty of every human citizen and friend of the forest. As matters stand to-day, the loss of this tree is far too imminent a possibility.

THE REVIVAL OF CLASSICISM AND THE LEGEND OF SOCRATES

By Dr. JONATHAN WRIGHT

A BOOK¹ remarkable for its research as to the sources of Plato has recently fallen into my hands, fresh from the press of Belgium. While it deals very little with the Nature Philosophers, who preceded him, but rather with the sophists and rhetoricians who formed the intellectual background in the life of Athens in the youth of Plato it has its interests for science. It incidentally sets forth the waves of mental activity which succeeded one another in the wake of the Ionian cosmologists. It is the product itself of the new interest in the classics and the story of Greek civilization. The book furnishes an illustration of the shifting of the currents of thought in our modern world and has a significance in itself. How far the wavelet of the modern revival of classicism is going to carry us it is at present impossible to say. It is interesting at least as a cosmic phenomenon and is worthy of the attention of psychologists and of sociologists alike. As remarkable as it has been, when so many of the practical results of materialistic research have emphasized the triumphs of science it has come with a suddenness which makes it seem unreal. Science has looked askance at classicism, with hostility even, since the time science began to knock insistently at the doors of universities and found classicism and the indifference, even the hostility, of the public barring its way to academic honors. It is hardly a hundred years since Mr. Pickwick was exposed to the widespread ridicule for having made the archeological discovery of

Bill Stumps

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His Mark

reported by Mr. Dickens, who also in the same narrative told of the effects of a supposed electrical phenomenon on the bald head of an inquisitive scientist, when it really had its source in the ready fist of Mr. Samuel Weller. Since the days when Mr. Dickens found it highly amusing and very lucrative thus to furnish laughter to his generation, scarcely three generations of men have passed away and for half that time archeologists and physicists, busy with elec-

¹ "La légende Socratique et les sources de Platon," par Eugène Dupréel, Bruxelles, 1922.

trical phenomena, have sat in the temples of fame and in the esteem if not the affections of the public. No one mocks them now, but there is undeniably a check to the exuberance of the hymns of praise for science.

The nature philosophers of old Greece came and went with scarcely less suddenness, and Aristophanes hung one up in the air in a basket on a wall at the theater for people to laugh at. It was not really a nature philosopher at all. It was an unusual philosopher. It was Socrates and he enjoyed the joke. Some of it was on Aristophanes, for Anaxagoras did not captivate Socrates as he did Pericles. The Athenians chased Anaxagoras out of Athens and they put Socrates to death. The Sophists had their day before Plato, and from Plato to Mr. Grote scarcely any one has given them a good name. Sophistical is a word of anathema, but the sophists were not bad fellows and were vastly more popular once than Socrates. The shifts of intellectual currents, the eddies of the mind of man in the mass are mysterious. Classicism coming back now may be one of them. One naturally asks a cause for this and the first response one hears is that it is the result of the unsatisfactory nature of the state of our spiritual affairs, the ethical, political and social status in which the world finds itself from following too trustingly the leadership of science. This is entirely too radical and too simple, though there has unquestionably been a chilling in the air in the attitude of the public mind toward science within the last few years, despite a rather awkward propaganda on the part of its friends. The benefits conferred on mankind, despite all the exaggeration and narrowmindedness of the appeal of the propaganda, has been too obvious for the world to disregard and turn elsewhere for a stimulus on that account. Man does not live from bread alone, it is true, but materialism has at least supplied a very large amount indeed of the necessities and comforts and perhaps has not been entirely recalcitrant in supplying some of the spiritualities of life for a generation past, but another generation approaches.

As a matter of fact, however, a love of the classics has not been dead. It has not even perished from the college curricula. It has ceased to be the somewhat superficial decoration and callow boast of the recent graduate in university honors, but there are men still alive or but recently dead who have loved Latin and Greek for their own sake all their lives long. In the intellectual life of France and England a hundred years ago the study of them was the occupation of the diligent and in social and political life distinction was with difficulty attained without at least a pretence to acquaintance with them. It happens that modern democracy arose and kept step with

the progress and the triumphs of science, and it was natural to suppose that both were more or less responsible for the decay of a knowledge of classical literature. Science has been, aside from certain bigots who infest every territory of thought, prompt to welcome a return and to disclaim any hostility to the study of the classics, but in this its historians are a little disingenuous. Democracy however has been ultra-scientific and has only of late given token that it too is looking towards an endeavor to place the study of the classics on another footing. But a short decade ago its eyes were exclusively fixed on the promise held out to it by science. In it democracy found its idols.

Has the great war disclosed their feet of clay? It is western Europe on which the blight of war has fallen most disastrously for civilization and it is France which again leads the intellectual world on the path back to the classics. The interest of American educators is but an echo of what is taking place in France. Education and public instruction there, as nowhere else, is a function of the government actively employed in its direction. There under a democracy which seems in many ways to have presented its worst facets to view educators are filling the school curricula with new courses of the classics. In England is observed under other aspects, but not so decisively, the same tendency, hastened rather than halted by the advent to political power of a government which is socialistic in its democracy. Lord Cromer, the conservative, Gilbert Murray, the liberal, have long upheld the tradition transmitted by Gladstone from an earlier generation of statesmen to a later; and now the avowed socialist, Ramsay MacDonald, has been urging in Scotland that educators instil the classics into the children of the common people, because he says unless higher education exists below as a stimulus it can never enduringly bloom at the top. You must exercise the wits of the people, if they have any, by interests in intellectual life. That is the only hope of modern democracy.

Herbert Spencer objected to the introduction of the metric system because it would exercise the wits of the people less to figure daily their weights and measures and prices in decimals than in the pounds, shilling and pence and the awkward standards which still exist there as with us. Socrates in the "Phaedrus" questions the advance made in civilization by the invention of letters. He tells the tale of their having been invented by Thoth in Egypt, who in the presence of King Thamus demonstrated their value to man in the cure of their folly and forgetfulness. The king doubts the wisdom of it. King Thamus, or Socrates for him, replied that letters in supplying the means of enduring memoranda enervate

the memory by taking its place. All these great men, Spencer, Socrates, Ramsay MacDonald and King Thamus, had the same goal in view—that of sharpening the wits and adding to the intellectual values of their fellow-citizens. The qualifications of the guards of Plato's "Republic" were chiefly educational. By the guards or guardians he meant the governing classes. They should be educated to know not only evil in the concrete when they saw it but evil in the abstract. They should receive the highest education possible.

Herbert Spencer, the last champion of the Manchester School, Socrates, the master builder of Plato's "Republic," and the socialist premier of England seem to have come together from the ends of the earth and the remoteness of ages, but in the mind of MacDonald existed, when he talked to the universities of Scotland, what is at the back of every intelligent man's mind, who stands at the crossways of modern democracy. He looks down all the paths of history and sees the wrecks the proletariat has made of social organization in more than one civilization and he holds desperately to the hope that here in America, where education is the law of the land, compulsory for every child, because any child may stand here where Ramsay MacDonald has in England, we may be training a more enduring democracy. The aristocracy of England built a mighty empire and has handed it over without bloodshed, with hardly a tremor to shake the ship of state, to an ultra-democracy. That is an achievement in itself almost unexampled in history. It was accomplished largely by virtue of that *sophrosyne* which Socrates taught in Athens twenty-four centuries ago. As we stand a little bewildered and much alarmed at those crossways of modern democracy, what better thought occurs to us than to teach our children the legend of Socrates?

By virtue, not of science, but of that wisdom which the history of mankind and the experience which it has gained since Socrates, whose seed fell on fertile ground, monarchy, oligarchy, autocracy, aristocracy have proved more enduring than any real democracy which has ever arisen. Along with science for his material welfare, along with religion for his spiritual nature, we must supply our republic with the *sophrosyne* of the ancient philosophers of Greece which mellows and broadens the mind. I fancy this train of thought has had something to do with the renaissance of the classics. It is rather this, I imagine, than the chill alone which is undoubtedly in the air for science when men think of the ghastly work it did for the destruction of millions of human beings and how since the war it has shown the same tendency to hide behind

locked laboratory doors as it did before the greatest catastrophe the world has ever seen. Men think of it as preparing a still greater one for the future and they shudder. They shrink from the law of the survival of the fittest to resist poison gas and dodge death dropping from the sky and lurking beneath the sea. They know very well what hatched these horrors of war. It was science. The evil in men seized upon them, but it was science furnished them as well as the innumerable benefits with which it has blessed mankind. Happiness, however, is of the spiritual nature of man, not his material comforts and the banishment of many of his physical sufferings for which he has alone to thank science, and now it has turned and inflicted hitherto unthinkable agonies.

There has been much talk of this kind in the last five years and it is very probable that in a way civilized man, as he is known to us western folk, in leaning away from science, first towards a sort of abyss of despair and pessimism, is now leaning toward the classics as hope springs ever anew again in his breast. When one tries to chart the broad sea of the soul and mind of man in the mass one can only deal with surmises. At any rate I lay down this book by a Belgian professor at Brussels and think of devastated Belgium and its heroic king—not a democracy exactly. I can only grope toward the opinion that deep in the psychology of vast numbers of intellectual people there is a revolt, largely inarticulate, against science, which promised us happiness and gave us misery. We were expecting bread and we got a stone. War is the father of all things and in so far science stood, if not as an enemy, at least in antithesis to the classics. The strong revolt against war carried with it some revolt against science and perhaps moved men a little toward the classics. In so far as this was influential the renaissance of the classics in the esteem of men will not be very durable, but as we said, it depends for its rise on something more stable than a temporary coolness towards science.

This is a fine book instinct with the scientific spirit of modern research applied to a profound and ingenious study of the origin of Platonic philosophy. If it is a revolt from science it has borrowed from it a thoroughness of method which even in science itself is more honored in the breach than in the observance. Dupré's tendencies are still more toward this breach in resting many of his conclusions on an insufficient basis of trustworthy fact. Despite the fact it is a work intended not only to study how far the real Socrates differed from the Platonic Socrates but, as the title indicates, to elucidate the sources of Platonic thought, the author does not make it very clear how much or how little the *Nature Philoso-*

phers had contributed to the groundwork of such knowledge of natural phenomena as Plato possessed, especially as to the physical basis of the thought associated with the senses. He does not point out with sufficient emphasis that Alcmaeon had already furnished the brain as the depot to which the five senses bring their messages. Though it was not accepted by Aristotle, who clung to the theory of Empedocles that this depot was the blood or its central chamber, the heart, nevertheless it was a theory of the predecessors of Plato, which the latter adopted. Nor does he make very clear how obscure was the idea of the synthesis of the senses from which most thought springs, how indeterminate was the line where sense cognition ends and thought begins—how indeterminate it still is. If he had done so the reader would then be in a position to appreciate what Plato added to what he inherited from his predecessors and that is the aim of the book beyond the mere legend of Socrates.

As pointed out by Beare² Plato takes this point up in the "Theaetetus" and states the problem clearly in the declaration that we do not see with the eyes nor hear with the ears, but through them. Aristotle did not advance the exposition of the question very much by inventing the term *common sense*, standing apart somewhat from the senses but made up of a synthesis of them all. It is mere logomachy, like his entelechy. Wrestle with the thing as we may we do not bridge the chasm yet. We know there is a connection of mind and sense, of feeling and sense, but what it is still defies definition just as thought itself does in a physical way. This may have been, doubtless was, a problem vaguely apprehended by his predecessors, just as the reality of Plato's "Ideas" can be traced out in the fragments we have of Pythagoras and behind him they disappear in the Orient. What Plato did add to what he had from Pythagoras, quite aside from his "Ideas," was the fact that not only is the mind the engine to utilize the stores the senses bring to the brain which memory guards, but it itself is the source of a sort of cognition which leads us to what is virtually metaphysics.

It is too often forgotten in accepting the current definitions of science that mathematics is a part of it and there is and always has been reason for arguing that mathematics do not rest purely on the testimony of the senses or the sequence of reasoning. They depend primarily on certain axioms from which there is no escape. We see the apples on the tree and note their form and color and the way they grow and the season in which they ripen, and if we have seen a lot of different kinds of apple trees and have classified them,

² Beare, John I., "Greek Theories of Elementary Cognition," Clarendon Press, 1906.

if we are a pomologist, or only a farmer even, we know the name of the variety. But if we want to know how many there are, though memory of past experience comes to our aid, we have to count them. We resort to a faculty of the human mind, how acquired we do not know. The embryologist can trace out the organs of the senses developing with the brain in the embryo, but what makes us able to count as well as smell we do not know. This faculty like that of sense depends for its efficiency on exercise. The dog and the tea taster have wonderfully increased their efficiency beyond that of the rest of us, but they both make mistakes. It is not only mortal to err in this way, it is even canine. But figures never lie, whatever the figurer may do. The ends to which the art of figuring may bring us are so far beyond the possibility of sense evolution that they flatly contradict sense, they outrage it in every way. Protagoras taught us man is the measure of all things, but these are only what the senses measure. Figuring has taught us indeed that "things are not what they seem." Now Plato did just that when figuring was in its infancy. He showed us clearly that the knowledge of number is quite aside from our knowledge of form and color. Dupréel traces the thought back to Pythagoras, to that time of vagueness in the differentiation of the senses from thought—when we thought with our blood and as every event has its antecedent this very likely is allowable, but to dig the diamond out from the dross is a more stupendous work of genius than finding a diamond mine. Pythagoras recognized the mystery in number and called it divine. In its origin we still recognize its mystery. Its separation from sense by the Pythagoreans and Platonists alike is emphasized in the asceticism of their followers.

As Gomperz³ puts it, there is nothing prevents us from thinking a swallow of water may moisten our throat, but that it will bring us no refreshment, yet it is quite impossible for us to think the part greater than the whole, that twice two is other than four. Plato in the "Euthyphro" and the "Republic" first defines exact science as resting on just this—the weighing and the measuring and the counting thus involved. The medical man and many another man of science has to depend on "feelings" and the testimony of the senses and even the higher mathematics can not entirely divorce itself at the start from the facts of astronomy revealed by the senses if he is to follow Newton and Einstein, but it advances chiefly by mathematical formulae, essentially based on quite a different faculty. We have passed far beyond the testimony of senses in our knowledge of the microcosm and the macrocosm and it is entirely

³ Gomperz, Theodor, "Greek Thinkers," tr. by Magnus, iv vols., 1908-1912.

incorrect to say we know all we do know from that. Of course there is little dispute as to this, but habit forces us to appeal to the senses to confirm the end results of the formulae and thus acting often at one end sense confirms what it denies at the other. In so far as reasoning is based on the senses the processes of thought are as often at fault. The synthesis of the senses, "*common sense*," helps us not at all. "*Realities*," whatever they are, escape our grasp with the help of these alone. Certain arithmetical and geometrical propositions we must accept without reasoning and without the testimony of the senses. In the order of these Plato places his "*Ideas*" as realities.

To the reader conversant with all this possibly the failure of Dupréel to develop it will be no loss, but his exposition of Plato's thought, whose source in this matter may be in Pythagorean doctrine, without it is apt to make small appeal to the less informed reader. The modern student of moral philosophy will fail to follow him when among these "*realities*" he places our notions of the good, the true and the beautiful. We place the conceptions of these in the collective sense of "*the tribe*." Justice also varies with longitude and latitude and time relations to them. Like the color of man's skin, what is true for one is not true for another, nor his idea of the good nor his notion of the beautiful nor what is due from one man to another. But when we come to mathematics twice two is four is as true in Alaska as in Patagonia, and it doesn't depend on the senses at all. It does not depend on the religious or political or ethnical view of truth at all prevailing among Esquimaux or Patagonians or exactly at all among people of much higher culture. It all goes back to simple counting—geometry and much of astronomy. We know the sides of a triangle subtend two right angles. We can take some calipers and "*prove it*," if we wish, by sight, or we can divide a square into four smaller squares and draw a diagonal from corner to corner and count one right angle and two halves, by seeing it is true, but in the mind lies the faculty of number which is independent of sight. Whether this exposition truly represents Plato's thought in the "*Theaetetus*" or not it is open to criticism, and whether the doctrine is true or not it makes small appeal to those worn with the disquisitions of a thousand philosophers since Socrates. By clothing it with some of the thought that is afloat to-day I have tried to familiarize it in such a way as to illustrate how, in other ways no doubt, it was familiar to the contemporaries of Socrates, for the path we have seen leads us back to Pythagoras and the divinity he quite plausibly makes of number. It is fundamentally a mysterious thing and man always

makes his gods out of mysteries. Vitalism has become a fetish with some, with some the germ plasm.

Dupréel assumes among his other conclusions from the "Dissoi Logoi" and other fragments, which have come down to us of those sophists before Plato, that Plato has made out of a real Socrates a mythical Socrates, which is probably true enough (even Plato can not portray a man to the life)—a Socrates superior to Protagoras who, according to Dupréel's interpretation of the information he derives chiefly from Plato, was a very superior person. As a matter of fact, however superior we infer from Plato Protagoras was, we are left to infer from the same source Socrates was supreme. Why accept one inference we get incidentally and reject the other we get from the author's evident design? The gist of many of the arguments is not beyond any one's comprehension, if clothed in the language which is redolent of contemporary thought in any period of culture, as the history of thought teaches us. Why was this refutation of Protagoras too much for the real Socrates? Dupréel is at pains to explain to us that Plato created Socrates very much as God created Adam—out of the dust of sophists. It is the art of Socrates which we are willing to believe Plato has heightened, not necessarily his mental acuteness in refutation of the doctrine of Protagoras in the "Theaetetus" that man is the measure of all things. Around this refutation is the play innumerable of thoughts which lead us to the answer to a doctrine which was old in the world even in Socrates's time.

Whether or not the real Socrates added anything new to the refutation it is impossible to say, but when Dupréel goes so far as to intimate that Plato and even Aristotle had no originality of their own he loses the ordinary sense of words. There is always an origin back of an origin, a cause back of a cause. It is well to drop such a conception from dialectics and think of thought historically as an impersonal process in which vast numbers of minds have participated and which only a few have illuminated. The greatest of these was that of Plato and the greatest work of art of Plato was Socrates as he appears in the dialogues, whether he created him or only illuminated him. For Plato to have created Socrates, as Dupréel seeks to show, like Adam out of mud, and to have had no part in the *Word*—in asking us to believe this Dupréel asks too much, but to say that the IVth century B. C. developed the ideas of the Vth century B. C., is something which might be said of every century. Socrates's death (399 B. C.) marks the beginning of the IVth century and to say as Dupréel does that Plato and Aristotle worked over the material of the Vth century,

great as it was, the age of Pericles, without adding anything to it, is suggesting something to which few will subscribe. But if that is so, Socrates at least belonged to the great century. Did Plato create him in the IVth century or did he grow in the greater century, as Dupréel calls it, and did Plato in the lesser century create a Platonic Socrates greater than the little Socrates in the greater century, a real Socrates, who captivated the mind of Plato, who knew him, and engaged the thoughts of Aristotle who lived in his tradition?

It is a commonplace of the history of ancient Greece to say that the age of Pericles was the acme of its glory, the age of Socrates. Dupréel falls in line with this sentiment, but to say that Plato and Aristotle were its heirs and that is all they were, as sometimes appears in his ardor to ferret out their predecessors, is doubtless going beyond his own thought. The rapidity of the waning of the power of philosophical thought after Aristotle may indicate that it had begun even before Plato had produced his best work. It is very probable that this is true. It indicates how powerless the mightiest minds are in the face of cosmic change, dependent on vastly more than the superiority of two or three individuals, but at the end of Dupréel's book he turns on Aristotle as well as Plato. He makes them both little better than the shapers of their predecessors' thought for eighty future generations of men. This book of the learned Belgian professor is one of very high merit and of absorbing interest, but this is nonsense.

SOME FEEDING PROBLEMS OF CHILDHOOD

By Dr. C. HILTON RICE, Jr.

MONTGOMERY, ALABAMA

IN THE SCIENTIFIC MONTHLY of December, 1920, Stefánsson, the Arctic explorer, reported some interesting observations made on feeding habits of men and dogs in the far north. He noted, for example, that the better bred man, one who had had opportunities of tasting a wide variety of foods, would more readily adapt himself to a radical dietary change—in short, was willing to try any food once. On the other hand, the poorer bred man who had been brought up on more or less restricted diet was most unwilling to try new foods. In his experiments with dogs Stefánsson observed that a pup fed on tainted meat for several months could not be induced to eat fresh meat. Also the puppies fed on fresh meat would not eat tainted meat. In both cases some of the dogs starved for a week before they would accept the change in diet. One of the dogs actually starved to the point of death and was saved only by a return to his accustomed food. A further observation was that a young dog that had been fed on a variety of foods, scraps from the table, etc., would readily eat almost any food offered.

To a striking extent I have seen these food reactions exhibited by the human young. In fact, to overcome food prejudices is perhaps the biggest problem in the feeding of children. Time and time again I have seen children who had reduced their own diet to a few—or even one—articles of food that could not be induced to taste other foods. A case in mind is that of a six-year-old boy whose diet consisted exclusively of cold biscuits. I was assured by the father that the child had taken no other food for several weeks and for some months he had declined to eat fresh vegetables and milk. Another case was that of a three-year-old child whose daily ration was a can of Eagle Brand Condensed Milk. Deprived of the condensed milk, this child starved for five days before he would take other foods.

There is an old belief still held by thoughtless people that instinct will guide the child to eat the foods it needs. In short, what the system naturally craves is best for it; what it dislikes is harmful. There never was a belief which has less foundation and fact than this. Every day of my life I see children who have appetites only for the foods that are slowly wrecking their health. Every

day I see children with positive prejudices against the foods that would give them health. The child who has the fewest food prejudices enjoys the best of life, because it is food more than any other environmental factor which guarantees physical well-being.

There is a rather common type of child who, allowed to eat what they like, will turn invariably to carbohydrates and the between meals eating of candy, cakes, etc. Such children from frequent eating are never really hungry. Owing to the character of their diet they become constipated. This slowing down of intestinal activity brings about a delayed emptying of the stomach which results in food retention and hyperacidity. It is the presence of this residual food in the stomach which destroys the child's appetite, and it is the hyperacidity which causes the pain in the "tummy" of which this type of child so frequently complains.

A solution of the problem presented here seems perfectly obvious. It appears to be merely a matter of giving diet lists and careful instructions to parents. However, the problem is very much more formidable than it seems, for it is deeply woven into the fabric of modern civilization. It involves a complete change of habits, and to change human habits is almost as large a task as one can undertake. To change the feeding habits of the child requires a changing of the parents' habits of dealing with their child. For a child that is allowed to eat anything that it likes, and at any time it likes, is almost invariably a spoiled child, and the spoiled child is a difficult case to deal with. To me he is a most pathetic and lonely figure in life, for nobody loves him except his parents and grandparents. But the fault is not his. The responsibility rests upon his parents. If they can not alter the relationship and gain control over the child's habits there is small hope of success in feeding such a case. However, if the child himself is a rational being, good results may be obtained by dealing directly with him. The number of such children that can be dealt with successfully depends upon the tact and patience of the physician.

For some years I have been preaching to parents the extreme importance of gaining control over a child in its second year. We long have known the perils of the second year. It is the most critical age of life, for it is the time when the foundation of food habits is formed. If a child gets off wrong, if he acquires dislikes for essential foods, these habits are likely to become fixed and permanent so that his whole future is affected. The longer I observe children and people in general the more I am convinced that many of the ills of middle life, constipation, visceral ptosis, chronic indigestion, gall stones, hypertension, gastric ulcer and gastric cancer

often have their origin away back in that remote period of childhood when, all unconsciously, the very foods that would have guaranteed long life and good health were excluded from the diet.

If ever there is a time when the firm hand of discipline needs to be used in the training of a child it is in this early, irresponsible age when the child is tasting his adventurous way through the lists of foods that make up the human diet. Here is the time to put into their little systems the A, B, C's of the vitamins which will protect them against more ills perhaps than we have yet suspected. Certainly there must be many border-line nutritional disorders which we can not recognize, yet which are due to a deficient vitamin or mineral content in diet.

It is not my purpose here to discuss the treatment of the individual case. I want rather to stick to the larger phases of the problem as they relate to preventive medicine. It isn't hookworm or malaria that is the plague of the south. It is malnutrition. Go to any school and watch the children as they file in or out and note what a small percentage are rosy and robust; how few look as children ought to look; how very few of them have the vigor and stamina and bloom of health that characterizes the wild creature that is nurtured by nature instead of by man. Observe their food habits and you will see the cause. They look exactly like the trash they eat. They remind one sadly of scrub cattle that have seen a hard winter on cornstalks and dead grasses.

In such a group of children one sees all grades of malnutrition, from slight anemia to actual illness from chronic gastric and intestinal indigestion. A symptom I have noted particularly is the marked extent to which the deficient diet is reflected in the child's temperament. A peppy, high-strung child may lose interest in life and sink into a mental state of moody or placid indifference; or a sweet-tempered child may gradually become extremely irritable and rebellious. I have had mothers note this symptom many times, and I often have observed a remarkable change in disposition follow a return to the normal diet. Since many of these cases are not treated at all or are treated unsuccessfully because of the lack of intelligent cooperation of the parents, there must be many children who pass into adult life with temperaments considerably changed from what they should have been.

There is a distinct type of malnutrition that is not uncommon, the spry, bright-eyed, sparrow-legged child with a bird-like appetite who feeds frequently on small amounts of an unbalanced diet. He is tense as a watchspring during the day, and his brain appears to dissipate energy at the expense of his body tissues. Of nights he

dreams, rolls in his sleep, grits his teeth and is up with the dawn to continue his high tension existence. To him food is merely something to relieve the physical discomfort which other people recognize as hunger. He passes on into adult life, and soon or late he discovers that he is hopelessly out of harmony with life. He then shows up at the office of the internist, who recognizes that the poor creature has been living on his nerve and mesenteric fat. The doctor puts the patient on a food and rest cure. The patient stores up a little reserve energy and a few pounds of fat, then he grows tired of rest and the eating of foods he never did like, laughs at the doctor and hits the trail again. In a short time he is back again in the clutches of his old food habits.

Right here I want to call attention to the tendency of mal-fed children to get back on their old diets. The longer a child has been on a one-sided diet, the stronger become his food prejudices and the more difficult it is to hold him to a balanced ration. It seems as though his tissues and organs become specialized, as it were, to certain kinds of foods, and always there is the old subconscious pull of habit that drags him back to his old ways of eating. That is why it is so difficult to feed the older child whose habits of diet have become fixed. That is why it is so extremely important to start the child on the right foods at an early age. To get this fact before parents is one of our duties in preventive medicine, for it is easier to prevent malnutrition than it is to cure it.

From what already has been done for the general welfare of the child there is good reason to hope that mothers in general will come to know more of the art of good cooking, and that both mothers and fathers will learn more of food values and the urgent importance of the early training of children to proper dietary habits.

Here in this land of plenty, of sunshine and fresh air, of milk, luscious fruits and fresh vegetables, of fresh eggs and fresh meats, it seems a crime against nature that any child should walk among us with the blight of malnutrition upon him.

SOME RIDDLES IN EPIDEMIOLOGY

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Riddles (A. S. *raedan*, to interpret), probably the oldest extant form of humour. They spring from man's earliest perception that there are such things as analogies in nature. Man observes an example of analogy, puts his observations in the form of a question, and there is the riddle ready made.¹

THAT there are riddles in epidemiology as in any other field of applied science is beyond peradventure. That it is often useful and sometimes necessary to list them and to examine them appears equally certain. Granting the chance that the stated or assumed analogy in the riddle may be fallacious, progress may follow as hard upon contradiction as upon elucidation.

We may say with Mr. Augustine Birrell that we

should not have ventured to introduce our subject with such very general and undeniable observations, had not experience taught us that the best way of introducing any subject is by a string of platitudes, delivered after an oracular fashion. They arouse attention without exhausting it, and afford the pleasant sensation of thinking, without any of the trouble of thought. But, the subject once introduced, it becomes necessary to proceed with it.²

We may consider that epidemiology, conceived in a narrow sense, is the study of the unusual prevalence of communicable disease in a population: it is the study of the natural history of epidemic occurrences of infectious or contagious diseases. I have said "in a narrow sense" advisedly for reasons which will appear shortly and which are related particularly to the unfortunate connotation which seems to restrict it entirely to the *unusual* prevalence of disease. In administrative epidemiology it is a matter of concern to determine the nature of the disease whose prevalence is considered unusual (minimizing by oversight for the moment the problem of first determining that an alleged pathological condition is unusually prevalent), and then to approximate an understanding of the pathways of infection. Epidemiological study must also consider the variables which enter as factors in the determination that a particular individual becomes ill and that his companion escapes the malady, that one sick person dies and another recovers, that one who has

¹ Excerpted from that much maligned but serviceable institution, the *Encyclopaedia Britannica*, eleventh edition, p. 316.

² "Obiter Dicta"; 1887, N. Y., p. 58.

suffered the visitation of an illness before appears to possess a hypersusceptibility to reinfection and another an immunity.

The great plagues of antiquity or our recent world-wide outbreak of influenza furnish us with examples of epidemics whose prevalence was so wide, whose severity so great and whose pathological picture in the infected individual so striking that their existence and their identities were unmistakable. Fortunately, great epidemics are comparatively unusual occurrences. It is not with them that the administrative epidemiologist is generally concerned. His attention is, and of necessity must be, continually focussed upon those epidemics which are always with us in civilized communities and which are sufficiently mild, localized or delimited in point of place, time or population group to be unrecognized except by the trained observer, which yet threaten significantly the health and the welfare of the community at large and which may, for lack of suitable combative measures, become widespread and devastating. This applies to communities in which sanitation is effectively practiced as well as in less advanced places. To go only one step further, then, a logical consequence of any program of *preventive* epidemiology is the continued study of the usual or normal occurrence of a particular disease which may or which from time to time does break out in epidemic proportions.

If we accept as a basic tenet of parasitology that for each particular infectious disease there is a specific causative micro-organism, it may appear to follow that wherever and whenever there are new cases of a particular infection there have been precedent cases of the same disease. And it was an accepted belief for a long time that fresh cases of a disease in a community, whether sporadic or epidemic, were indubitable evidences that there had existed in the community—or had been brought into it—antecedent cases of the same disease.

In the eighties of the last century it was still held with respect to certain diseases—notably cholera and typhoid—that the virus, although present in the dejecta of the patient, causes disease only after secondary decomposition in a suitable organic soil. So recently as 1873, Sir Charles Murchison said of typhoid fever—to which he had given the name *pythogenic* (filth born) *fever*—"it may be generated independently of a previous case by fermentation of faecal and perhaps other forms of organic matter." This view has gone by the board and the doctrine that disease is born in filth remains with us merely as the umbilical stalk to account for the inheritance by the modern health officer of the burden of back-yard sanitation.

At the same time when the pythogenic theory was accepted it was also held that with respect to such diseases as smallpox the sick patient himself—not his *dejecta*—is the nidus of infection and that personal contact, or, as we sometimes say, contagion, is the principal if not the sole pathway of infection and transmission from person to person. Consequential to such a view there was developed the technique of isolating the sick and holding them in quarantine for such a time as was described by the period of infectivity for the disease. Even up to a decade ago it was tacitly accepted that the contagious diseases could be completely stamped out if only all persons sick with them could be isolated in strict quarantine. In a modified sense we still adhere to such a belief with respect to a few diseases. But for the most we now know that the communicable diseases can not be controlled either in their usual (endemic) or in their epidemic forms through this means alone.

The appearance in 1903 of Robert Koch's "Die Bekämpfung des Typhus"² following his study of typhoid at Trier marked the beginning of a new era in epidemiological thought. He demonstrated that persons themselves healthy, particularly persons who had previously survived an attack of the disease, may be carrying and continuously or intermittently excreting typhoid bacilli virulent for others. And the appearance in the United States in 1910 of Dr. Charles V. Chapin's book, "The Source and Modes of Infection," marks the beginning of modern concurrent epidemiology, the process of ferreting out by a slow and plodding process, one by one, the individual persons whose infections threaten families or small groups. Quoting the pregnant paragraph which opens the second chapter:

That there are occasionally seen mild cases of the infectious diseases difficult or impossible to recognize has long been known. That such cases are rare has always been generally believed. That the germs of disease can maintain themselves and increase in number in a person without causing any symptoms at all was until recently scarcely thought possible, and the idea that such latent infections are extremely common would have been scouted as preposterous. Even to-day the facts are denied by many sanitary officials, and there are comparatively few who recognize the frequency with which mild atypical forms of disease and healthy "carriers" of germs are found, or realize the tremendous importance which such cases have in the spread of the contagious diseases. Undoubtedly the most fruitful medical discovery of the last century, and perhaps of all time, was the discovery of the parasitic nature of the infectious diseases. Probably the most important discovery bearing on preventive medicine since the demonstration of the bacterial origin of disease is that

² Read before Der Kaiser Wilhelm Akademie, November 28, 1902.

disease germs frequently invade the body without causing disease. . . . The term "carrier" is applied to those persons in whom pathogenic micro-organisms exist, but who, nevertheless, show no symptoms. Such carriers are rarely found by the health officer, and the very mild cases also naturally escape notice and are hence called by the English "missed cases," i.e., cases which fail of recognition.

For such diseases as scarlet fever or smallpox there is but little evidence to warrant the belief that carriers ever or frequently occur, although cases sufficiently mild to escape detection are common in both. Isolation and quarantine of the sick and of persons who have been in contact with them proved successful in the limited control of these two diseases, although the etiological agents were unknown.⁴

On the other hand, for diphtheria and typhoid fever, to choose only two examples from a long list, it is clearly established that healthy carriers of potentially virulent organisms are not unusual. Thus it has been found in various studies that virulent diphtheria bacilli can be isolated from the throats of 0.1 to 1.5 per cent. of healthy persons chosen at random and in much larger proportion among persons who have been in intimate contact with diphtheria patients. It is also known that from three to ten persons harbor non-virulent diphtheria bacilli for each carrier of virulent organisms.⁵ With respect to typhoid fever it is clearly established that approximately one third of all convalescent cases continue to discharge typhoid bacilli for two to four weeks after the onset of the disease and smaller proportions for progressively longer periods. In the population at large it may be conservatively estimated from available data that one person in one or two thousand is a typhoid carrier. Need I stress further the significance of the carrier or his relations to the spread of infectious diseases in a population which appears to be free from sources of infection? Indeed, we have come to accept the outbreak of infectious disease in a community free from precedent frank cases as reasonably certain proof of the existence of a healthy convalescent or preclinical carrier of the virus of that disease. In *ye goode olde dayes* public health was concerned with the environment of man; modern public health is concerned with the individual. "The old sought the sources of infectious dis-

⁴ Within the last few months independent investigators in Chicago and New York have published the results of researches which tend to incriminate a particular hemolytic streptococcus as the causative organism in scarlet fever.

⁵ In their careful study of the incidence of diphtheria carriers in Baltimore schools, Doull and Fales (*Amer. Jour. of Hyg.*, 1923, c, 604-629) found 409 (5.25 per cent.) carriers of morphological diphtheria bacilli among 7,790 children selected at random, and 136 (1.75 per cent.) carriers of virulent diphtheria bacilli.

ease in the surroundings of man; the new finds them in man himself" (Hill). At this point we may ask the question: Why does one individual who survives an attack of typhoid fever or of diphtheria become free of the infecting organism and another remain a carrier for a longer or shorter period? Why does one person become acutely ill after the introduction of the bacilli into the body and another remain healthy although he harbors the virulent organisms and provides the pabulum for their propagation? These are riddles.

Before entering into the discussion of unsolved problems associated with specific communicable diseases it is perhaps *apropos* to indicate briefly the technique which is used in administrative epidemiology in determining when an epidemic exists.

Because of their devastating propensities and because of the dramatic characteristics which have grown up about them since their complete or partial eradication, the report of a single case of plague, cholera or leprosy is sufficient to arouse the vigorous activity of health authorities. Dysentery and typhoid do not frighten us exceedingly—we have some with us in the country the year round and are less cautious than contemptuous with them—unless there be (as we sometimes say) too much of them. Pneumonia, tuberculosis, diphtheria, scarlet fever, measles, mumps, influenza, colds and many other infectious diseases are treated with scant respect unless they recur in proportions which can not be considered within the usual safe, healthy endemic limits and take on epidemic proportions. In these instances the problem arises: Where shall we draw the border-line between endemic and epidemic frequencies? In many health departments the standard which is used in measuring the severity of reported disease is the number or rate of similar reports in the corresponding periods of the two or three preceding years. In some departments a datum known as the median endemic index is used, calculated from the reported cases of disease for the same week or month for the five or ten preceding years, excluding epidemics in the previous years' data. The uncertainty which attaches to the definition in statistical measurements of endemicity or epidemicity precludes entire impartiality in measurements of this kind. Nevertheless, it is generally possible to arrive at reasonably certain conclusions by simple statistical comparisons, whether or not a particular disease is exceeding its endemic privileges in a frightened, propagandized community.

For more reasons than one we may look askance, if we will, at the all too well-accepted notion of permissible endemic prevalence of disease. The slogan of the New York Department of Health, one of the best and most wisely administered departments in the United

States—"Public health is purchasable. Within natural limitations any community can determine its own death rate"—does not overstate the case. With respect to the control of endemic disease it would probably explain itself more completely if the phrase, "within natural limitations" were expanded to "within financial and natural limitations." Assuming that a legislative body were capable of so unusual a commitment as the provision of an adequate budget, the natural limitations on the authorities would be defined only by the inadequacies of administration and of natural knowledge. We can not doubt that in such circumstances the control of epidemic as well as of endemic disease would be far more effective than it is to-day in any civilized community. Indeed, I make so bold as to say that a primary riddle is how to attain provision of adequate funds for the administration of a program of preventive epidemiology.

Let us consider briefly the prevalence of the infectious diseases, including in the category those diseases which are transmitted from person to person (with or without the intermediation of an insect, rodent or other secondary host) through the agency of "foods, fingers, fomites or flies." If we examine a list of the principal causes of death, we find that the thirteen which headed the bill of mortality for 1920 for that part of the United States for which reasonably accurate statistics are available (the Registration Area) accounted for nearly two thirds of all deaths. Further, we find that approximately 30 per cent. of the deaths are attributed to infectious diseases—pneumonia, tuberculosis, influenza, diphtheria, whooping cough, measles and typhoid and scarlet fevers; that another 30 per cent. is charged to the so-called *degenerative diseases*⁶—endocarditis and organic diseases of the heart, acute nephritis and Bright's disease, cancer and cerebral hemorrhage and apoplexy; and that all other causes of death combined make up the remaining third of the causes of mortality.

Now statistics, as the vernacular has it, are notably in poor repute. You can prove anything with them, it is said. Perhaps you can, to the gullible one, but you can't—sometimes with statistics or without—to the skeptical one. The principal cause of their shady reputation is the uncritical use of such data as I have just cited. For example, our official tables tell us that pneumonia caused 137.3 deaths per 100,000 persons in 1920 (10.5 per cent. of all deaths). Upon inspection we find that this includes "bronchopneumonia" as well as "lobar pneumonia" and "pneumonia undefined."

⁶ So-called principally because their incidence is greatest in the years of advanced adult life and because they are incidental to organ failures.

Now we are inclined to believe that a very considerable proportion of cases and of deaths of lobar pneumonia are initiated as primary pneumonic infections, but we have very little ground on which to estimate the true etiology of "bronchopneumonia" or of "pneumonia undefined." At least a very considerable proportion of these cases represent pneumonia secondary to colds, influenza, bronchitis, tuberculosis, organic pulmonary, circulatory and nephritic defects, accidents and injuries and inoculative infections secondary to them. Concerning the alleged mortality rates from diphtheria, whooping cough, measles, typhoid and scarlet fevers (when combined these constituted the causes of 20 per cent. of the deaths of 1920) we can, with reasonable surety, accept them as understatements of the actual severity of these foes of humankind. It would be a bold health officer who would contend that in *his* community all the deaths caused by these acute, infectious diseases are accurately diagnosed and reported as such on the certificates of death. Concerning tuberculosis and influenza, I should like to postpone discussion of their prevalence.

Apart from the less common infectious diseases which have been omitted—notably plague, typhus, cholera, dysentery, smallpox, yellow fever, leprosy, anthrax, rabies, meningitis, tetanus, infantile paralysis, etc., and those less fatal but more widespread causes of sickness, malaria, hookworm disease, the venereal diseases and their sequelae, it must not be conceived that we have exhausted the toll of the infections of man. The evidence from pathological and from statistical studies is convincing that many deaths which are apparently caused by organic or functional defects of the heart, kidneys or other vital organs are, in a certain sense, attributable to the infections of childhood and early adult life. There is little doubt, I think, that injuries to the kidneys in non-fatal cases of scarlet fever and to the valves and muscle walls of the heart in diphtheria play significant rôles in the premature decadence and breakdown of these organs in later years of life. Furthermore, even a single remark will serve to recall that certain of the infectious diseases are important causes of morbidity but not of mortality and hence do not appear to be of significance when our attention is focussed upon tables of mortality.

It is not my plan to undertake an extensive analysis of epidemiological literature nor to run the gamut of unsolved problems from actinomycosis to zymotic diarrhea. I wish only to indicate by brief discussions the status of knowledge (and of ignorance) in a few fields which will serve as prototypes. To this end I have chosen some riddles in etiology, in the significance of telluric phenomena,

in age, sex and race factors and in the epidemiology of plague, influenza, tuberculosis and malaria.

I may recall to your minds that there are great gaps in our knowledge of etiology among the communicable diseases. We do not know or are uncertain of the causative organisms in colds, influenza, smallpox, measles, mumps, poliomyelitis (infantile paralysis), rabies (hydrophobia), typhus fever, Rocky Mountain spotted fever, foot and mouth disease, and many other important diseases. In only the most recent years in the one case and within the year in the other have the spirochetal organisms of yellow fever (*Leptospira icteroides*, Noguchi) and the hemolytic streptococcus of scarlet fever (Dick and Dick; Dochez) been described with some measure of convincing evidence.

There are equally great gaps in the study of the factors which result in the association of certain diseases as sequelae to others. Thus, for example, it is not known why bronchopneumonia is so commonly a concomitant or sequel to influenza or measles or why that curious disease, lethargic encephalitis ("sleeping sickness"), appears to follow in the wake of epidemic influenza. And, to reiterate, almost nothing is known of the factors which determine the establishment of the carrier state in typhoid fever, diphtheria, perhaps in poliomyelitis, infectious (cerebro-spinal) meningitis, pneumonia and other diseases.

The epidemiologist has been accustomed—since the rise of the bacteriological fashion—to scoff at the statements in older literature concerning the relations between epidemic prevalences and cosmic or telluric phenomena associated with sunlight, weather, rain, wind, earthquakes, ground-water level, etc. The evidences which have been coming out of the studies on the vitamin deficiency diseases, notably rickets, in recent years, have begun to teach him that he may stay to pray. If recent findings in the value of heliotherapy, especially in relation to organic and cellular physiology, as is so clearly evidenced in rickets and in surgical tuberculosis, have demonstrated anything, they have shown that sunlight plays no inconsiderable rôle in the maintenance of the normal functioning of the organism. The far-reaching effects of sunlight are reflected in the physiology of parts remote from the surface tissues. These and other environmental factors may prove to be far more significant in the elucidation of certain problems in pathology than has until recently been suspected.⁷

⁷ Witness the recent studies of Colebrook, Eidinow and Hill on the effect of radiation upon the bactericidal power of the blood (*Brit. Jour. Exper. Path.*, 1924, **1**, 54; and of Kugelmas and McQuarrie on the photoactivity of substances curative of rickets (*Science*, 1924, **60**, 272).

The whole field of age, sex and race proclivities towards the infectious diseases reflects an unfortunate state of ignorance. Certain diseases have such characteristic age distributions that they are known as children's diseases or diseases of adults or diseases of old age. In some cases it appears that the age distribution is determined by acquired immunity. For example, a disease such as measles attacks nearly all children in a community and bestows upon them an immunity which is lasting; a large part of the adult community can not therefore "take" the infection. In diphtheria, the offspring of a mother who carries in her blood antitoxin is highly immune in the first months of life. This passively acquired immunity of the infant is soon lost, for reasons unknown, and is replaced by a high susceptibility. In later life the individual—even he who appears not to have had the disease—manifests a high immunity to diphtheria. Whether this is acquired through mild, unrecognized infections or through changes in organic structure we do not know. Many differences in relative susceptibilities between the sexes appear to be associated with secondary sex characters (differences in organic structure and function), but they are veiled in uncertainties. Differences in racial susceptibilities—I shall have occasion to refer to a few in greater detail later—are considered by some to be secondary to environmental factors, difference in diet, habits of work, play and sleep, differences in over-crowding and opportunities for infection by contact, etc.; by others they are held to be partly or largely determined by hereditary and congenital forces. When the riddles are answered we may see much that is accurate in both views. A truth, said Birrell, does not always exclude its contradictory.

The historian Gibbon tells us that:

If a man were called upon to fix the period in the history of the world, during which the condition of the human race was most happy and prosperous, he would without hesitation name that which elapsed from the death of Domitian to the accession of Commodus [from 96 to 180 A. D.].

Upon this remark we find that Noah Webster (in his absorbing work, "A Brief History of Epidemic and Pestilential Diseases," Hartford, 1799) comments:

It is certain that, at this time, the Roman Empire was in its glory, and governed by a series of able and virtuous princes, who made the happiness of their subjects their principal object. But the coloring to the happiness of this period is far too brilliant. The success of armies and the extent of the empire do not constitute exclusively the happiness of nations, and no historian has a title to the character of fidelity, who does not comprehend, in his general description of the state of mankind, moral and physical, as well as political evils.

What of the prevalence of disease in this most happy and prosperous period of civilization? What shall we say of the historian's judgment when we find that this choice object of historification was (as Vaughan⁸ has aptly put it) "preceded by, begun in, and closed in, pestilence." Of the epidemic of 68 A. D. Tacitus tells us:

Houses were filled with dead bodies and the streets with funerals; neither age nor sex was exempt; slaves and plebeians were suddenly taken off, amidst lamentations of their wives and children, who, while they assisted the sick or mourned the dead, were seized with the disease, and perishing, were burned on the same funeral pyre. To the Knights and senators the disease was less mortal, though these also suffered in the common calamity.

In the year 80 A. D. when, it is estimated, the population of Rome was something over a million, at the height of the epidemic, the plague carried off 10,000 persons a day. And the pest visited Rome at least six times again during Gibbon's "most happy and prosperous" period. How many times it visited various parts of Europe we can not know with certainty. The Levant and adjoining countries, situated at the gateway between the East and the West, have been plague centers for at least 3,000 years. Long before the explanation for the phenomenon was available it was known that where man travelled, there travelled the plague.

The first specific world-wide epidemic (or, as we say in the jargon of epidemiology, *pandemic*) of plague originated at Pelusium in Egypt in 542 A. D. Thence it was carried by merchants and travellers to all the then known world, carrying death in its right hand and hunger and privation in its left. Then slowly it died out; and the world was ready for the second pandemic of bubonic plague. This probably started in Mesopotamia, an old endemic center, in the eleventh century. Its spread, probably greatly assisted by the returning Crusaders, soon attained world-wide proportions and justly earned the name "Black Death." It ravaged Europe through the Middle Ages. "Towns were left empty and all trade was at an end. All feared 'the pestilence that walketh in darkness,' none knowing when their turn would come to be smitten." In 1664-65, the year of the Black Death in London, the disease claimed for its own some 70,000 persons in a population of half a million. Defoe's "A Journal of the Plague Year" vividly portrays from hearsay the life of that year (he was but a child in swaddling clothes when the events which he describes occurred). The discovery of the new route to India by way of Cape of Good Hope and the subsequent avoidance by commercial travellers of the endemic plague centers of Asia Minor resulted in the gradual cessation of the pandemic.

⁸ V. C. Vaughan, "Epidemiology and Public Health," 1923.

To-day the world is in the grip of the third great pandemic of bubonic plague. It appears to have taken its origin in the town of Junnap Fu in China in 1871. It spread to Hongkong in 1894; thence to India, where in ten years it carried off six million persons. It has knocked at the doors of all the countries of the world and in only a few has it been refused admittance. In recent years it has claimed some six hundred thousand deaths per annum in India. Within the fortnight we have learned that there were reported 11,388 deaths from plague in India in the period November 11 to December 8, 1923, and 379 deaths from October 1, 1923, to January 15, 1924, in the Kalmuck region of Russia. In the United States it has established itself in four endemic centers, California, New Orleans, Texas and Florida, and has appeared in a total of 389 cases in the years 1900-1920.

Now, it is as clearly established as is anything in epidemiology that plague exists in at least three forms in man. In the *bubonic* and *septicemic* types the organisms invade the blood stream and set up pathological processes in the blood, lymph glands and various tissues from which they can not escape. Hence these forms of the disease are not, in the usual sense of the term, contagious. In the third form, rarer and more highly fatal, the *contagium vivum* invades the lungs, sets up a pneumonia and is found in virulent form in the sputum. It is highly contagious. Also, it is clearly established that plague is primarily a disease of the tarbagan and the rat (and possibly of other rodents) and only secondarily of man.⁹ It is spread through the agency of the flea, an associate of both animal hosts and is caused by a small bacterium, the *Bacillus pestis*. One attack of the disease usually confers a lasting immunity. Preventive epidemiology depends chiefly upon control of the rat and the flea, somewhat upon the use of a protective vaccine and a curative serum, and in the pneumonic form of the disease upon measures of quarantine.

I have presented here at some length the outstanding characteristics of plague epidemiology more because they serve to illustrate many riddles than because plague is prevalent. Of itself, plague is not sufficiently widespread in the United States to constitute an immediate problem. But it is a threat which hovers over us. We are led to question: Whence does it come? We can not answer with certainty. It appears to be a chronic disease of rodents which on occasion becomes severe and highly fatal and gives rise to notable

⁹ In the United States plague has been found in the gray rat (*Mus norvegicus*), the black rat (*Mus rattus*), the white-bellied rat (*Mus alexandrinus*), in the mouse (*Mus musculus*), in one species of wood rat (*Neotoma*) and in a field rodent in Louisiana.

epizootics among these animals. The association of dead rats lying about the habitations of man and the outbreak of the disease in the human population is at least as old as the Book of Samuel. Dr. McCoy of the United States Public Health Service has pointed out, however, that the evidence is not convincing that the epizootic and the epidemic always run simultaneously.¹⁰ The third great pandemic, that which is with us to-day, appears to have started in Tibet with some hunters of the marmot, a rodent which has long been known to carry the infection chronically. In the United States chronic infection with plague is widespread in the Californian ground squirrel (*Citellus beechyii*), a reservoir of death and destruction which we must hope will never be tapped.¹¹

When plague first appeared in San Francisco in 1900 it was confined chiefly to the Chinese quarters. It came at a time when the relations of the rodent to the spread of the disease were unknown and when knowledge of such relations played no rôle in the combative measures employed. Yet the disease did not spread extensively among the white populations living in adjacent quarters. A few years later there was a recurrence of the disease and the whites furnished most of the victims. These anomalies have never been explained.

Why does the plague suddenly flare up in its rodent hosts? What is the nature of the parasitic specificity of the *Bacillus pestis* for the rodent and for man? How has this organism attained a high pathogenicity for man, so high that it causes the destruction of its host and thereby ends its own organic continuity? Why does it die out so long as there are rodents and men to feed upon? Why do some countries remain free from plague, their populations being apparently plague-immune.¹² Why is there a measured parallelism between plague immunity in a country and a high general average

¹⁰ G. W. McCoy, *American Journal of Hygiene*, 1921, I, 186.

¹¹ The United States Public Health Service is carrying on an extensive anti-plague campaign.

¹² The flea, it appears, is not a specific but only a casual host. It was once thought that all fleas found on rats were of the same species. Hirst showed in 1913 that fleas of the species *Xenopsylla astia*, isolated in Colombia, do not readily bite man at temperatures above 80° F. He found also that of 788 fleas caught in Madras City, India, all were of the species *X. astia* and thereupon indicated a likely explanation for the relative immunity of this city from plague. Later (1922, 1923) Cragg collected nearly 25,000 fleas from all parts of India and found among them members of the species *X. astia*, *cheopsis* and *brasiliensis*. In plague areas *X. cheopsis* predominates; in plague-free areas, *X. astia*. His work suggests that the permanence of plague implantation in a community depends upon the species of flea which inhabits the locality. Further ecological study will perhaps explain the differences in the distribution of fleas.

atmospheric humidity? What are the factors which determine the appearance of plague in the pneumonic or the bubonic forms? Why is pneumonic plague never found in rats; why does it occur commonly in squirrels; why does it more commonly appear in man following squirrel than rat infection? These are a few problems which call for solution. That they are not unique for plague but are known in analogous forms in the epidemiology of other diseases will appear shortly.

In September, 1918, epidemic influenza appeared in malignant form on Commonwealth Pier in Boston.¹³ Two months later there was scarcely a community in the United States free from it. It had spread like wild-fire through the population, numbering twenty million cases and nearly half a million deaths, a far greater toll than the war can boast. It took rich and poor, old and young, robust and feeble, male and female. In most places it was bewildering in the acuteness of its onset and the amazing rapidity of its spread, running at a pace which recalls the plague. It generally lasted some 8 to 12 weeks and tended to recur some 7 or 14 weeks later. We know that it has visited the civilized world before in pandemic form with some regularity and at least with undiminished severity certainly since the sixteenth century. Eichel¹⁴ has grouped the outbreaks of influenza into four epochs (1557-80; 1729-43; 1824-51; 1889-1900) and finds that the intervals between them have been diminishing (172, 95, 65 and 26 years, respectively). Epidemics of influenza in historical times can be recognized by the recorded descriptions of the acuteness of onset of the symptoms in the individual, the notable, extreme prostration and weakness unaccompanied by specific signs or symptoms sufficient to account for them, the rapid spread of the disease and by the striking characteristics—often encountered in the recorded testaments of influenza visitations in the past—that so many are acutely, painfully sick and that so few die. Indeed, it is almost safe to say that *per se* influenza never kills; death is due to secondary causes and complications, notably to bronchopneumonia.

The epidemiological study of influenza is unusually complicated by the mildness of the disease in many persons and hence the facility with which it may be spread and because the lack of clinical specificity renders early or certain diagnosis extremely difficult. The rapidity and generality with which it moves through a population argues for spread through personal contact or some other

¹³ The first outbreaks in the United States appear to have occurred in certain army camps in the spring.

¹⁴ Quarterly Publication of the American Statistical Association, December, 1922, pp. 446-454.

common medium. The uncertainty which attaches to its true etiology renders more specific information difficult of attainment. A number and variety of micro-organisms and filterable viruses have been incriminated, but none holds an unequivocal claim to a causative relationship. Recurrences of epidemic influenza in the winters subsequent to that of 1918-19 have provided some meager opportunities for the further study of the disease; but comparatively little has been discovered. The etiology of epidemic influenza remains a riddle.

We may turn our attention for a moment to the alleged origin of epidemic influenza in endemic or inter-epidemic influenza. A malady "influenza" reported on death certificates is well known, year in, year out. In "normal" years it is reported as the cause of more deaths than typhoid fever or diphtheria. Opinion is at variance, however, as to its precise relation to the disease, "epidemic influenza." There can be little doubt that in inter-epidemic years the name "influenza" is used to describe various acute catarrhal and bronchial inflammatory conditions, the name being a hang-over from previous epidemic years. It has usually appeared that as the time after a great pandemic lengthens, the name is used less and less until it comes to be unknown to a considerable part of the lay or medical population; it remains only as "a mere tradition in medical nomenclature." Professor Jordan¹⁵ quotes Mrs. Carlyle to the effect that:

Medical men all over the world have merely entered into a tacit agreement to call all sorts of maladies people are liable to, in cold weather, by one name, so that one sort of treatment may serve for all, and their practice be thereby greatly simplified.

And one is tempted to agree that therein lies more truth than jest. I can not enter into a detailed discussion of the arguments which have been adduced by numerous writers, pro and con, on the identity of epidemic and inter-epidemic influenza. It must suffice to indicate that opinion is at variance and the problem is still with us awaiting further evidence and more careful study. In certain respects epidemic influenza appears to differ from its inter-epidemic namesake. Thus the epidemic disease occurs chiefly in young adults; the inter-epidemic disease in the very young and old. The negro is less or the white man more susceptible to epidemic than to inter-epidemic influenza. The influenza epidemic of 1918 is also sharply marked off from the endemic influenza of preceding years

¹⁵ Jordan, E. O., "Inter-epidemic influenza," *American Journal of Hygiene*, 1922, II, 325-345.

by a higher mortality among white males than among white females and by a relatively increased mortality in colored males by comparison to colored females.¹⁶ Also, it appears—so far as data are available to test it—that the findings from the vital statistics of the 1918-19 epidemic agree with those from the 1889-92 epidemic in those respects in which they differ from the findings on inter-epidemic influenza. It is recognized, of course, that the difference may be due to deaths which are attributable to other causes but which are ascribed to influenza in inter-epidemic years and confuse its true statistical characteristics.

To those students of epidemiology who consider epidemic and endemic influenza the same disease, the chief problem at issue resolves itself in the search for an explanation of the remarkable change in the invasiveness and malignancy of the infecting organism or of changes in the factors of immunity in the host which will account for the apparent differences between the diseases. To those who adhere to the view that "endemic influenza" is a misnomer and bears no close relationships to "epidemic influenza" the riddles which remain unanswered are: Does epidemic influenza maintain a thread of continuity from epidemic to epidemic? Why does the disease sometimes take on epidemic proportions? Why does the epidemic die out? Or does it arise suddenly, spontaneously, *de novo*? It is almost gratuitous to add that the answers can not be given.

Shortly after the outbreak of influenza it became evident that in some cities the fatality of the disease was far greater than in others. The statistical data on mortality from influenza have been studied very thoroughly in attempts to ascertain the causes for the observed variations among communities. It was discovered by Raymond Pearl and confirmed by Winslow and his associates¹⁷ that there is a high statistical correlation between the explosiveness of the outbreak and the normal death-rate from pulmonary tuberculosis, organic diseases of the heart, organic diseases of the kidney or of the normal death-rate from all causes of death in years preceding that of the epidemic. This correlation—the tendency of a community to have a high death-rate in otherwise normal years and to have suffered severely from epidemic influenza—remains an inter-

¹⁶ L. K. Frankel and L. I. Dublin, *American Journal of Public Health*, 1919, 9, 731-742; J. D. Craig and L. I. Dublin, *Transactions of the Actuarial Society of America*, 1920, 20, p. 134; E. O. Jordan, *loc. cit.*

¹⁷ R. Pearl, *Public Health Reports*, 1919, 34, 1743-1783; C. E. A. Winslow and J. F. Rogers, *Journal of Infectious Diseases*, 1919, 26, 185-216; R. Pearl, *Public Health Rep.*, 1921, 36, 273-298; C. E. A. Winslow and C. C. Grove, *American Journal of Hygiene*, 1922, 2, 240-245.

esting discovery. What does it mean? That the observed relationship, measured in statistical terms, is real can not be questioned. It must be remembered, however, that the relation between two groups of statistical data may be one of very high correlation and yet need not be direct. Indeed, it may be very remote. In the present instance the high correlation does not necessarily mean that *because* in a given community the normal death-rate from certain organic degenerations was high, influenza was severe. That may have been the case. It is equally possible, however, that some common factor (*i.e.*, differences in proportions of persons of different nativities, or the presence in the population of a particular community of micro-organisms of especial virulence) may be found accountable for both. Recently, Professor Huntington¹⁸ has discovered that there is a significant statistical correlation between the death-rate from influenza and pneumonia and the weather. He thinks it suggests that "the favorable conditions of the air were the greatest factor yet detected in helping the people of the United States to ward off the influenza in the fall of 1918." If one recalls, however, that this is argument *pro hoc, ergo propter hoc* his conclusion must be accepted with caution. These statistical discoveries have added two more significant riddles to our already long list in epidemiology.

I wish that it were possible to discuss here in greater detail the problems associated with the alleged periodicity of influenza and to tell you of Dr. Brownlee's statistical machine, the Juggernaut "periodogram" which, built out of the statistics of epidemics which have passed, marches on into the future and ventures crushing predictions of epidemic returns. But I may only mention it in passing and indicate that with influenza as with certain other diseases a sort of regularity appears in the intervals between successive epidemic waves. Accepting the fact, it is uncertain whether the explanation is to be sought in factors of temporary immunity following infection, in telluric relations or in cyclical variations in the virulence of the infecting organisms.

Of all the infectious diseases, tuberculosis is the commonest in occurrence and the most wide-spread. In the United States alone, it is estimated that 160,000 persons die each year from this one disease.¹⁹ And in certain other countries, for example, in Germany and France, the mortality is even higher. It may be estimated that of the 110 million people living in this country, nearly ten million (something fewer than one in each ten) are doomed

¹⁸ E. Huntington, SCIENTIFIC MONTHLY, 1923, 17, 462.

¹⁹ Estimated on the basis of 1.5 deaths per 1.0 reported death.

to die from this dread "white plague" unless its onslaught is checked. When this appalling loss is considered in light of the fact that tuberculosis falls especially during the period of the individual's greatest usefulness—75 per cent. of the deaths occurring between the ages of fifteen and sixty—and when premature death brings the greatest burdens upon the families of the deceased, the tremendous importance of anti-tuberculosis measures and campaigns can be fully recognized. During the past fifty years the mortality from tuberculosis has been declining rather steadily. However, modern methods of control have so far made but little apparent impression upon the gross amount of infection. The social and economic conditions of the mass of the population are related in a peculiarly pertinent manner to the determination whether an individual will go through life with healed tuberculous lesions or will succumb with clinical tuberculosis. The usual methods of preventive epidemiology are, in a considerable measure, inapplicable to tuberculosis control. The present-day campaign against the disease is largely dependent upon attempts to change certain social and economic relations and personal habits of living.

For the purpose of our discussion we may consider that in civilized communities tuberculosis occurs in two forms: (1) an acute febrile disease, observed principally among children, and bearing the stamps of the infectious maladies such as typhoid fever and diphtheria; and (2) a chronic disease, often years in duration, most commonly pulmonary in localization and particularly associated with the years of young adult life. From the findings at autopsy upon persons who have died from causes of death other than those associated with the germ of tuberculosis and from the so-called von Pirquet test (the application of extracts of the bacillus of tuberculosis to the abraded skin) it has become clear that among civilized peoples nearly every individual who has attained the years of adult life—if not actively sick with tuberculosis—harbors the latent infection.

Among primitive peoples, on the other hand, the von Pirquet tests are negative before tuberculosis is introduced among them by their civilized deliverers from the ways of barbarism; and the disease, when first introduced, runs the course of the infectious type and is not partial to any particular age group. It kills rapidly and indiscriminately. Robert Louis Stevenson tells us:²⁰

The Marquesan race is perhaps the handsomest extant. Six feet is about the middle height of males; they are strongly muscled, free from fat, swift in action, graceful in repose. To judge by the eye, there is no race more

²⁰ "In the South Seas," p. 33.

viable; and yet death reaps them with both hands. When Bishop Dordillon first came to Tai-o-hae, he reckoned the inhabitants at many thousands; he was but newly dead, and in the same bay Stanisla Moanatini counted on his fingers eight residual natives. The tribe of Hapaa is said to have numbered some four hundred, when the smallpox came and reduced them by one fourth. Six months later a woman developed tubercular consumption; the disease spread like a fire about the valley, and in less than a year two survivors, a man and a woman, fled from that new-created solitude. . . .

According to Calmette, an English speculator introduced into Lima two thousand natives of the Marquesas. In less than eighteen months three fourths of them were dead of tuberculosis. In Queensland—something of a resort for tuberculous Englishmen—the Polynesians constitute but 2 per cent. of the population and furnish 22 per cent. of the deaths from tuberculosis.²¹ When first becoming acclimated to life with the white man the African negro shows the same high susceptibility to acute infectious tuberculosis. Similarly, among the American Indians high death-rates from tuberculosis suggest the maintenance of a primitive susceptibility.²² Following dissemination of the disease among these peoples there appears among the survivors a heightened resistance to the disease. It appears, then, that the susceptibility of the civilized man's child partakes of the character of that of the primitive man. The *comparatively* lesser frequency of acute tuberculosis among these children (only a small proportion of them succumb to it) argues, however, that *tuberculization* of a population results in the acquisition by the newborn of a distinct, if partial, immunity—an immunity sufficient to prevent the tuberculous infection of childhood from taking on an acute form in all but a few children if it is insufficient to exterminate the microbes which they have come to harbor. (It is believed that the organisms are walled off in the lungs, lymph glands or other organs in childhood and provide the nidus for an autoinfection which we recognize in later life as chronic tuberculosis.) How comes the white man's child by this relative immunity? Is it inherited or is it passively transmitted in foetal life from the tuberculized mother? We do not know.

Carefully conducted surveys in representative communities have demonstrated that nearly 1 per cent. of the persons examined were suffering from active tuberculosis, while somewhat over 1 per cent.

²¹ G. E. Bushnell, "A Study in the Epidemiology of Tuberculosis," 1920, p. 60.

²² Tuberculosis is not unique in these respects. Primitive peoples have shown extreme susceptibility to measles. The same phenomenon on a less striking scale is suggested by recent experiences in army camps. Among recruits from rural areas measles incidence was higher than among recruits from the cities.

more were arrested or partially healed cases. Thus a total of some 2 per cent. of our population may be considered tuberculous. How do they acquire the infection? Available evidence is convincing that part of it—a small part—is acquired through the ingestion of infected meat or milk from tuberculous cattle. For the rest, it is believed that the infection gains entry in early life from direct contact with the persons of the tuberculous or with objects in the environment which they have infected. Do the invading organisms gain entrance through the digestive tract following ingestion or through the respiratory tract following inhalation or directly through the circulating blood following penetration of mucous membranes of the nose and throat or of the epithelia of the tonsils? There is no single answer. Among those who are most competent in this field there is a sharp difference of opinion. We are persuaded by the positive evidence which has been adduced for each of these pathways of infection to believe, for the while, that they all serve. Extended researches in the future may supply us with a better basis for elucidation of this problem.

The incidence of tuberculosis mortality in the community is not evenly distributed. Thus among persons of different race stocks living side by side in New York state²³ the lowest mortality rate from tuberculosis was found among the native born of native parentage. The foreign-born and their native-born offspring agree much more closely with each other in these respects than with those who are native-born of native parentage. Yet very important differences are observed among them. Thus, males born in Ireland showed rates 3.5 times as great as native males,²⁴ males born in England, Scotland and Wales 1.3 times as great and males born in Russia only 0.7 times as great. There can be little doubt that these marked variations are considerably determined by economic differences; but there can be equally little doubt that they are in part determined by qualities, still largely obscure, transmitted from parent to offspring.

I have presented to you, at some length, the views which have been current among students of tuberculosis epidemiology and which were crystallized more or less independently by Bushnell²⁵ in the United States, Cummins²⁶ in England and Calmette²⁷ in

²³ L. I. Dublin, *American Economic Review*, 1916, 6, No. 3; SCIENTIFIC MONTHLY, January 1922, pp. 93-103.

²⁴ Not necessarily of native parentage.

²⁵ *Op. cit.*

²⁶ *International Journal of Public Health*, 1920, 1, 137-171.

²⁷ L'Infection bacillaire et la Tuberculose chez l'homme et chez les animaux. Translation by W. B. Soper and G. H. Smith, Baltimore, 1923.

France. Their work had led us to believe that the relatively chronic nature of tuberculosis among civilized peoples is due principally to the immunity acquired by the individual after occult infection in childhood. So long as we accepted the studies which showed that nearly every one who had attained adult age was thus infected and protected it had seemed reasonable to hold that wide-spread, mild infection in the early years of life was highly desirable. Indeed some of the leading scholars²⁸ in this field advocated the artificial infection of young children with suitably prepared doses of non-virulent tubercle bacilli as a preventive against the dangers of chance infections with virulent strains which are so promiscuously distributed by careless or unwitting consumptives. In the light of information which has become available during the past few months, we are compelled to reexamine these tenets. We are now informed that skin tests for tuberculosis made in St. Louis, New York and Philadelphia indicate that at the age of 15 less than half of our children are infected as compared with four fifths for children in French, Swiss and Italian cities and more than nine tenths for Vienna.²⁹ The decline in the proportion of positive skin reactors among American children, when coupled with the significant fall in the death-rate from tuberculosis in recent years, compels us to ask the questions: Was the extensive latent infection of children the cause or the result of the wide-spread infection of the adult population with chronic tuberculosis? In the future shall we look with fear or with favor upon declining childhood infection? The nature of the anti-tuberculosis program will depend largely upon the answers we accept.

Though it may be paradoxical, it is true, I think, that there is no necessary parallelism between the extensiveness or completeness of knowledge concerning a communicable disease and the effectiveness of its control. Acceptance of the empirically established principle "cleanliness is next to godliness" resulted in the essential elimination from large areas in the civilized world of several epidemic diseases. Some of these, like typhus fever, have reappeared in Europe since war-time disruptions made abidance by either cleanliness or godliness highly inconvenient. If one considers the history of smallpox and recalls its one-time scourging dissemination, he is impressed by the comparative effectiveness with which the disease has been controlled despite our ignorance concerning the nature of the causative organism. This lack of infor-

²⁸ Vide Calmette, *loc. cit.*

²⁹ N. Y. Tuberculosis Association Bulletin, March-April, 1923; Barchetti, *Archiv. f. Kinderheilk.*, 1922, 71, 180.

mation has not appreciably interfered with the program of prevention and elimination by vaccination.

It is significant, perhaps, to draw an example contrariwise. Recall that we are in possession of a more complete armamentarium against malaria than against any other important communicable disease. Yet it remains one of the most wide-spread of all. We have perhaps more exact knowledge and are bothered by fewer important riddles in malaria epidemiology and yet it counts its victims by the millions. The following pertinent indictment I cite from the late Sir William Osler's brilliant summary "The Evolution of Modern Medicine":³⁰

It is difficult to draw comparisons in pathology; but I think, if a census were taken among the world's workers on disease, the judgment to be based on the damage to health and direct mortality, the votes would be given to malaria as the greatest single destroyer of the human race. Cholera kills its thousands, plague, in its bad years, its hundreds of thousands, yellow fever, hookworm disease, pneumonia, tuberculosis, are all terribly destructive, some only in the tropics, others in more temperate regions: but malaria is to-day, as it ever was, a disease to which the word pandemic is specially applicable. In this country and in Europe, its ravages have lessened enormously during the past century, but in the tropics it is everywhere and always present, the greatest single foe of the white man, and at times and places it assumes the proportions of a terrible epidemic. In one district of India alone, during the last four months of 1908, one quarter of the total population suffered from the disease and there were 400,000 deaths—practically all from malaria. To-day the control of this terrible scourge is in our hands. . . .

It may be estimated that we have to-day several million active cases of malaria in our southern states; and there probably are many more malaria carriers than cases. Last month the Health Section of the League of Nations reported that during the first 10 months of 1923 some 4,900,000 cases of malaria were reported in Russia, as compared with some 2,900,000 in 1922. It is also stated that the reported number of cases is probably less than half of the actual number, as only the most severe cases are seen by physicians, and the number of patients applying for treatment in the outpatient departments of hospitals at malaria stations has been restricted by the limited amount of quinine available for distribution.

Under the press of unusual circumstances and associated with the disruption of social machinery the best of epidemiological information may prove incapable of coping with an administrative problem. I would not give the impression that there are not many gaps in our knowledge of the natural history of malaria. For example, we do not know very much about the infecting organism,

³⁰ New Haven, 1921.

the nature of the toxic product which it produces, the explanation for the specificity between the parasite and its anopheline host, the reason for certain curious seasonal distributions of malaria or the relation between these distributions and the malignancy of the disease. Some years ago, Ross and Thomson showed that between relapses in a patient the parasites persist in the body, but where and in what stages is not known. I cite the case of malaria merely because I would urge the caution that between the availability of precise information and the effective control of an epidemic disease there are difficulties of personnel and administration which may not be minimized.

For many of the communicable diseases the education of a population through a long period of years is an essential preliminary step to an effective program of control. Witness the case of diphtheria. The large-scale production and distribution of antitoxic serum made possible a reduction in mortality, but it scarcely modified the extent of morbidity. In future decades education of the people to acceptance—nay, to demand for—the universal use of the Schick test to determine susceptibility and of toxin-antitoxin mixture to produce artificial immunity may result in the eradication of this disease.

In the domain of natural science we are grown accustomed to recognize much that is unknown: but we do not readily conceive of anything that is not knowable. The riddles in epidemiology which have received such cursory exposition here we must accept only as temporary gaps. The interest which they hold for us is grounded, I conceive, on the opportunities which they suggest for speculative and experimental research; but not because (as Goethe remarked of miracles and the miraculous): "Das Wunder ist des Glaubens liebstes Kind."

JAPAN IN 1923

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On our way to and from Siberia, in the summer of 1923, my wife and I had some interesting experiences in Japan, most of which were neither planned for nor anticipated. We left Yokohama on the night train, Friday, June 2. When daylight came we had left the coast region, and were going through a hilly country, and a little later a farming region, where the rice-fields were all under water, some with young rice plants, others being planted, and some being gone over preparatory to planting. Presently we came to Maibara Junction, where we had to change, and waited a considerable time. In the waiting room we saw a well-dressed Japanese gentleman, carrying with his hand baggage a dainty little cage containing living fire-flies (Lampyrid beetles), which are of course luminous at night. When our train came, we got into a second-class car, with seats running lengthwise on each side, and noticed that many of the passengers rested at full length, their heads on air pillows which they brought with them and inflated. Passing near the shore of the great Lake Biwa (the word biwa means a loquat), we entered a series of beautiful valleys, and winding through the mountains, in due course reached the seaport Tsuruga, from which we were to sail for Vladivostock. Taking rikishas down to the wharf, we found our ship, the *Hozan Maru*,¹ with steam up and almost ready to go.

So far, the Siberian Expedition had encountered no serious difficulties, but here our troubles began. The people at the local Osaka Shosen Kaisha (steamship) office looked us over, and examined our return tickets, and declared that they did not recognize the signature. We had purchased the tickets at Cook's in Yokohama, after a visit to the O. S. K. office in that city. There was indeed the difficulty that our passport was without visa for Russian territory (none being obtainable in the United States or Japan), but we had other papers which we supposed satisfactory, and which in fact proved quite adequate when we finally reached Vladivostock. Not only did the Tsuruga steamship office refuse to honor our tickets, even after much argument, but we were subjected to a very thorough cross-examination by the chief of police, whom we came

¹ Hozan means high or fine, perhaps to be compared with hosanna in the Hebrew scriptures. Maru is steamship.

to know later as our very good friend, Mr. Tsuji. Long after, we were informed that the office at Tsuruga suspected that our papers did not truly describe our intentions, and that we were in fact Russians in disguise going over to plot in some way against the Soviet Government! My beard doubtless lent support to this hypothesis. Had we been such dangerous characters, the vessel might have been seized, and the captain imprisoned, so the company was taking no chances.

Thus, unexpectedly, we were halted at Tsuruga, with no chance of leaving for Siberia until the *Hosan Maru* sailed again a week later. We accordingly established ourselves in the "European" half of the small Kumagai Hotel and tried to make the best of what seemed to be our misfortune. As it turned out, nothing could have been more fortunate, for we not only made many interesting observations in natural history, but saw the real Japan, as we should not have done in a tourist resort. Tsuruga is a large seaport closely built in the usual Japanese style, with no very large or fine buildings. The inhabitants are purely Japanese, except for an occasional Russian, now dressing and living in Japanese style and evidently very poor. There is not a single American or Englishman in the whole place. The people are nearly all Buddhists, but there are about 50 Christians, who keep up a small Methodist meeting-place and a Salvation Army depot. Although English is taught in all the schools and has been for a number of years, very few can speak it, any more than our people can speak the French or Latin they have been taught. Looking for an American, we noticed near the wharf a large building inscribed Standard Oil Company of New York, and going to the office found an English-speaking Japanese, Mr. Okano, who greeted us in the most friendly manner and did much to assist us in many ways. We also became well acquainted with the police officer, Mr. Tsuji, who took us to have tea in a Buddhist temple. Our shoes removed, we sat on the soft matting, surrounded by the images and inscriptions appropriate to the place, while out of the open door we saw a typical Japanese garden, with dwarf trees and pools in which gold-fish swam. The great inscription just above us read (as we were told) "After the rain, clouds of incense arise from the flowers." We were given tea in dainty bowls, and California sun-kissed raisins. In such surroundings one wondered whether the beauty and sense of repose were a reflection of the inborn Japanese temperament or whether the religion had molded the people to its type, after centuries of devotion. It is perhaps like asking whether there were first butterflies or flowers adapted to be pollinated by them. We were taken to see the National School for girls, presided over by Mr. Otsuki. The classes visited

were one in English (taught, of course, by a Japanese), one in flower arrangement (using the iris and chrysanthemum), and one in the etiquette of serving a cup of tea. Evidently the graces of Japanese life are not left entirely to racial temperament or instinct. We also visited the playground, where the girls, in short skirts of European type, were taking vigorous exercise in a great variety of ways. The new Japan is unanimously going to school, and it is a great sight to see the streets filled with children every morning. The youngsters regarded us with interest, but always with politeness, though to them we must have had many of the qualities of a circus.

America was represented in Tsuruga by the "movies." We went to the cinema theater one evening, and saw the comic adventures of a policeman in Chinatown, San Francisco, and another American play showing all sorts of extravagant adventures connected with the "evil eye," evidently made on the coast of California. After these absurdities came a Japanese play, which so far as we could see was of a dignified character. Two interpreters or speakers followed the pictures with dialogue and explanations, one to give the male, the other (in squeaky tones) the female voice. We felt very indignant that American life should be so misrepresented abroad and thought that some concerted effort should be made in this country to send worthy and characteristic films to Japan and elsewhere. Apparently the purely commercial interests can not be trusted in these matters, and thus great opportunities are lost and great harm is done.

The narrow streets are solidly lined with low wooden houses, open in front, and with nearly always something offered for sale. Entering these little shops, one is not pressed to buy and sometimes it is difficult to find the owner. It would seem easy for passers-by to take the goods, but there is no pilfering. Swallows build their nests under the eaves or on the rafters, flying in and out continually. No doubt they aid greatly in keeping down the mosquitoes, and we found these insects comparatively scarce, in great contrast with conditions on the Kudia River in Siberia. The species at Tsuruga, determined by Dr. Dyar, proved to be the ordinary form of Europe, *Culex pipiens* Linnaeus. In these Japanese towns, there is constant danger of fire, and we heard it said that the average life of a house in some places was not over seven years. At one o'clock one night we were wakened by a great turmoil and hastily dressing went out in the street. There was a red glare in the sky, and every one seemed to be up and running toward the fire. We followed the crowd and found buildings blazing close to the girls' school. The fire-fighting arrangements

were primitive, but the great number of men engaged and the close proximity of water made it possible to subdue the flames, which we feared at first might destroy the whole town. The crowds were kindly, and we felt perfectly safe in their midst.

Tsuruga not only has its temples and temple gardens, but also a fine park. At the entrance to the park is a notice in English and Japanese, the former as follows:

NOTICE

The following actions are strictly forbidden:

- I. To shoot or catch birds or beasts.
- II. To burn fire or amuse with fire-works or make any other dangerous tricks.
- III. To do any kind of business without permission.
- IV. To draw a cart of any description through the park, except the road, public or private.
- V. To cut or remove trees or shrubs.
- VI. To harm the landscape of the park.

A very noticeable feature was the large number of book-stores, and in one of them we saw a picture of Darwin prominently displayed.

Taking a walk in the vicinity of the town, I was much pleased to find on a mulberry tree quantities of the extraordinary scale-insect, *Takahashia japonica*, which I described in 1896. It resembles our cottony-scale of the maple, but the white ovisac becomes greatly lengthened, and the shrivelled female is left suspended at its free end. I found that the insect was very well known to Mr. Toyoda, of the Plant Quarantine Station at Tsuruga, where I saw a collection of Coccids and a good entomological library. In general, I found scale-insects scarce at Tsuruga, contrary to expectation. Scanty material of a possibly new *Phenacaspis* occurred on a native plant, and the beautiful *Orthezia japonica* of Kuwana was common on low herbage by the roadside.

Going north from the town, we passed through a large tunnel and came out near the quarries where limestone rock is obtained and used in the manufacture of lime. The road runs close to the shore of the bay and is cut in the side of steep forested slopes, which are covered with the most beautiful trees and shrubs. The aspect of the flora is almost semitropical, very different from the strictly temperate (Palaearctic) flora of the Maritime province of Siberia. A very fine tree, with somewhat the aspect of a basswood, was in full flower, and attracting vast numbers of humble-bees, the humming of which could be heard for some distance. The tree was

determined for us by Mr. Rehder as the Rhamnaceous *Hovenia dulcis* of Thunberg, the original describer evidently having noted its fragrance. It is the only species of its genus, so far as I can learn, but extends as far as the Himalayan Region. The commonest of the humble-bees was the *Bombus diversus* of Smith, but there were several other species, including the one I described several years ago as *Bombus sapporoensis*. This latter, marked with yellow, black and red on the abdomen, was extraordinarily "mimicked" by a Syrphid fly of the genus *Mallota*, found at the same place. This was the more surprising because these flies do not, so far as we know, have any biological relation with *Bombus*. This *Mallota*, a large and handsome species, proves to be new to the U. S. National Museum, but it can not be identified because no copy of Matsushima's great work on the insects of Japan, in which it is probably described, is available. I tried to procure a copy, but the whole reserve stock was destroyed at the time of the earthquake.

Bees were not as numerous at Tsuruga as I expected, although there were many flowers. The only new species obtained was a leaf-cutting bee (*Megachile*). We were pleased to find the males of the great carpenter bee flying round in circles. F. Smith, of the British Museum, long ago described it as *Xylocopa circumvolans*, although he said nothing about the habit which might have suggested the name. Near the tunnel we found the so-called Japanese beetle, *Popillia japonica* of Newman, which has become such a pest in New Jersey, but seems quite harmless in its native home. We had met Messrs. Clausen and King in Yokohama, where they were stationed for the purpose of investigating this insect for the U. S. Government and determining its natural enemies. In this undertaking they have been very successful, as will appear in the course of time. On the coast of Siberia we also found *Popillia*, very like the Japanese form, but a different species.

Various butterflies were noted, especially some very large and handsome species of *Papilio* (swallowtail), having quite a tropical aspect. At the same time, we noted a form of the "small copper," *Chrysophanus phlaeus*, a species which we took a few years ago at the other end of the Palearctic Region, in Madeira. The particular form of the copper butterfly occurring in Japan has just (1924) been named *japonica* by Edmund B. Ford.

Particularly interesting to me were the snails of the region near the limestone quarries. The great *Helices*, generally referred to *Eulota* (subgenus *Euhadra*), were represented by three forms, one of which I have since described as new. These mollusca have a broad dark stripe down the back of the animal, and the internal anatomy is so different from that of true *Eulota* (which we found

in Siberia) that I consider *Euhadra* of Pilsbry a valid genus. Another very attractive snail was the fusiform sinistral *Clausilia japonica nipponensis* of Kobelt, which I found in some numbers on the face of a rock. Although much work has been done on the rich snail-fauna of Japan, there is still much to do, especially in studying the distribution, habits and anatomy. It would be a good idea to explore the coasts and islands by means of a large boat, in which it would be possible to sleep and cook. The many sheltered harbors afford ample protection from rough weather. It must be said of the snails at Tsuruga that they have an Oriental, not Palearctic aspect, totally different from the snail-fauna of the Siberian coast.

We collected only a few plants, for the names of which we are indebted to Messrs. Maxon (ferns), Killip, Rehder and Nakai. A brief account of them will serve to convey some idea of the flora:

Apocynaceae. *Trachelospermum asiaticum* Nakai, closely related to the fragrant cultivated Star Jasmine, which comes from China. The leaves of *T. asiaticum* vary greatly, from lanceolate to subovate, even on the same twig. If fossilized, they would probably be referred to two species.

Campanulaceae. *Campanula punctata* of Lamarek, a fine large "bluebell" with whitish, finely spotted flowers, when well developed more than an inch and a half long. We observed the same species again in the coast region of Siberia.

Hypericaceae. *Hypericum patulum* Thunberg, a large St. John's Wort, with opposite leaves and yellow flowers.

Leguminosae. *Indigofera pseudotinctoria* Matsumura, a close relative of the well-known Indigo plant. It has small pinnate leaves.

Saururaceae. *Houttuynia cordata* Thunberg, with cordate leaves having long slender tips. This is closely related to the American (California to Rocky Mountain region) *Anemopsis*, these plants being isolated remnants of a group which was doubtless once much better developed.

Rhamnaceae. *Hovenia*, mentioned above.

Saxifragaceae. *Deutzia scabra* Thunberg, a beautiful shrub well-known in cultivation, but here in its native habitat. The genus has a number of species in Asia and one in Mexico; we should accordingly expect to find it fossil in the United States, but so far it has not been recognized.

Verbenaceae. *Callicarpa japonica* Thunberg, with small flowers, and large broad leaves with long slender tips, suggesting the "drip-tips" of so many plants in the moist tropics.

Vitaceae. *Parthenocissus tricuspidata* Planchon, closely related to the Virginia Creeper, and having very broad leaflets.

The ferns were extremely fine and varied; a few that I collected proved to be *Asplenium trichomanes* Linnaeus (also common in America), *A. incisum* Thunberg, *Adiantum pedatum* Linnaeus, *Cyrtomium falcatum* (Linnaeus, filius), *Polystichum* sp., *Pteris* sp., *Onychium japonicum* (Thunberg), *Dryopteris varia* (Linnaeus) and *Coniogramme japonica* (Thunberg).

By the end of the week, thanks to Mr. Clausen and other friends in Yokohama, our difficulties with the shipping company had been overcome, and with much politeness they offered us the best cabin on the boat. We were seen off by a delegation of Japanese, bringing presents, and departed with a very warm feeling for the Japanese in our hearts. We hear it said that the Japanese do not like Americans, but no people could have been more friendly than the citizens of Tsuruga. We had been isolated in a purely Japanese town, and had every opportunity to notice signs of dislike or hostility, but found none. Should we behave as well to a couple of Japanese coming unexpectedly among us, with no special recommendations?

It was not until the end of August that we returned from Siberia. We were met by our friends Okano, Tsuji and others, and had the pleasure of presenting to Mr. Tsuji a fossil plant (*Sequoia*) from Siberia—the first fossil he had ever seen. He begged for a second specimen, to place in the museum of the girls' school. The evening of that day Mr. Tsuji appeared with a roll of cloth under his arm. "This," he said to me, "will be your kimono; my wife and daughter will sit up all night to make it for you, and I will bring it to the train." So it was, for although the train went at about seven in the morning, and the station was about a mile from the center of the town, Mr. Tsuji and other friends were there to see us off. The kimono was worn with pleasure and comfort in Yokohama, but eventually went to a refugee after the earthquake.

On our way back we made an excursion to Kyoto, and then visited the fine university and were shown over the extensive biological laboratories. We noticed all the standard European and American biological journals on the table in the library. Leaving Kyoto for Yokohama, we stopped off at Gifu to see the famous old entomologist Mr. Nawa and visit his museum. We had telegraphed that we were coming, and were met by a young entomologist, a specialist in Coleoptera, who however knew hardly any English. After a very long ride on the crowded street-car we reached Mr. Nawa's home, to find that he was confined to his couch and unable to work. He welcomed us very kindly, and gave us a copy of the volume issued in his honor; but as he spoke no English, and no interpreter could be found, it was impossible to converse. In the museum we saw many interesting things, especially a series of well-preserved fossil insects of Tertiary age, which unfortunately have never been described.

Leaving Gifu late at night, we found it impossible to procure berths in the sleeper, and had to rest as best we could on the long seats of a second-class car. Reaching Yokohama next morning, we

proceeded to the home of Mr. Charles Bishop, at 222 A Bluff, where we had the good fortune to stay for several days. Mr. Bishop is a Methodist missionary who has been in Japan over forty years, and from him we learned a great deal about the country. Guided by him, we visited the Imperial University and Methodist College in Tokyo, only a couple of days before their destruction. We took passage on the *Empress of Australia*, to sail punctually at noon on September 1. I had taken our boxes, containing the Siberian collections, to the ship the day before. On the morning of September first we accordingly took rikishas down to the wharf, and looked up our cabin, leaving our hand baggage. There was already a stiff wind, and I recalled afterwards that my rikisha man's hat blew off as we crossed the canal, and narrowly escaped falling into the water. Everything being arranged, we went back into the city to see some of our friends, particularly Mr. P. E. Jenks, the admirably efficient U. S. vice-consul, and to spend the last of our Japanese money. As we went in and out of the well-known stores and purchased dainty and beautiful things, we little imagined that of all we saw before us, only what we took away would be saved from utter destruction! Had the earthquake occurred an hour sooner, we should have been in the thickest part of town, with every probability of losing our lives. Returning to the ship, which lay alongside the wharf, we stood on the deck watching the crowd which had come to say good-bye. Every one who did not belong on board had been ordered off, and following the picturesque Japanese custom, those on the wharf held paper streamers of all colors, the other ends of which were in the hands of their friends aboard. As the boat pulls out, the friends on shore run along the wharf, until at last the ribbon-like paper breaks, and that is final adieu. It was three minutes to noon, when without the slightest warning, the great ship was violently shaken, as though some explosion had occurred in her interior. Some one said "earthquake," and when we looked down, we saw that both ends of the wharf had collapsed, though fortunately the part on which most of the people stood was still intact. Looking toward the city, we did not at first appreciate the magnitude of the disaster. Large buildings still apparently stood; we could not see that their roofs and floors had utterly collapsed. Almost immediately there were great clouds of dust, and then smoke and flames, obscuring the view. The *Empress* made no attempt to start on her voyage, and in fact her propeller had got tangled up in the anchor chains of a steamer just behind, and she was disabled. The wind, which we had already noticed in the morning, now increased in violence, blowing off-shore. Consequently smoke and sparks were blown all over the vessels in the harbor, and it was only through

the industry of the crews in playing water over them that they were kept from burning. Fortunately, the *Empress* had new hose-pipes, in the best of condition. The earthquake having come just at the hour when people were cooking the noon meal, fires started everywhere as the wooden houses collapsed, so that before long the whole place was like a gigantic furnace. Many people caught in the wreckage and unable to extricate themselves were burned to death. One heard afterwards of heartrending cases, as that of a man whose wife was caught under a heavy timber and who had to be dragged forcibly from the approaching flames by some of his friends, while his wife perished before his eyes. Other cases ended more fortunately; thus there was a man who saw the foot of a woman sticking out from a mass of débris and got the impression that she might still be alive. So he went to work and extricated her, saving her life. They made their way toward the water-front, and what with his exhausting labors, and the sight of so many dead bodies, and the fearful heat, the man now fainted, and the woman managed to drag him to safety. Eventually they both reached a ship. The Japanese people showed the utmost fortitude and played up splendidly, excepting certain officials, who apparently could not act without orders. There were of course some criminal acts, as in all such crises, but it is better to remember rather the numerous deeds of kindness and fidelity. Thus a man described to me how the Japanese chauffeur saved his wife and child. They were in the automobile, not far from the waterfront, when the earthquake occurred. The chauffeur had a family of his own, but he seemed to think only of saving the American woman and her little child. Guiding them to the edge of the harbor, he waited for the chance of a boat. The fire increased, and at last he said, "I think you must jump in the water, with the baby, and take the chance of its being drowned." However, just then a boat appeared, and it was not until the woman and child were safe on a ship that the Japanese went off to try to find his own family. In another case, a certain man who had an office down town, was unable, on account of the fires, to make his way to the top of the Bluff, where his house, containing his wife and child, was situated. The next day he set forth again, although friends tried to dissuade him, saying that all was certainly lost and he would only risk his life for nothing. But he made the journey, and found indeed that his home was gone and his wife dead, but under a bush sat the Japanese nurse with the baby. She had been there, waiting, for 24 hours, and simply said: "I knew you would come." These cases are not rare exceptions, but rather typical of what was going on everywhere.

The most complete destruction, prior to the spread of the fire, was probably in the heavy English-built buildings along the Bund and Water Street. So far as we know, not one person came alive out of the Imperial Hotel. We saw a man whom we knew, who worked in Cook's office. He was saved, because he was in the street (in a rikisha) at the time of the quake; but he hastily made his way to the office, and found nothing but ruins, without a single survivor among those who had been within. A few (including a woman) managed to swim out to the ships, but many more entered the water, and, immersed up to their necks, waited for help. Thus some stood for hours, ducking their heads as the heat became too intense. The ships' boats were out all night rescuing people and very soon every vessel in the harbor was crowded with refugees. The park and baseball ground were full of people, who found here a place of comparative though by no means perfect safety. Estimates of the loss of life can never be exact, but it was enormous. Up on the Bluff, there were more or less isolated houses which did not burn, and fortunately one of these was that belonging to the American entomologists, who were not in town at the time. I saw Mr. Clausen later at Kobe, and he greatly feared for the safety of his valuable notes and collection of the Hymenopterous family Chalcididae, which represented a very great addition to the known Japanese fauna. It turned out that the Japanese servants had had the sagacity to hide these materials under the floor, where they escaped the looters, and so these valuable scientific materials were saved.

On September 2, the *Empress* had a very narrow escape from destruction, owing to the ignition of a large tank or barge of oil, which was in front of the Standard Oil building. The burning oil drifted rapidly toward the vessel, and it was only with difficulty that she was got out of the way in time. She was assisted by a Dutch steamer, which, as we learned later, was herself full of combustibles, and was taking big chances. In spite of this peril, there was no panic on board, though all the passengers were ordered to the side of the boat away from the oil, and sailors played water all over the other side. However, that burning mass, had it caught us, must have destroyed the vessel and all on board.

The *President Jefferson* came in from the south, and as the *Empress* was disabled, we hastily transferred to her, taking the more precious part of our collections in hand bags. The *President* put back to Kobe with a load of refugees, and to get food and water, and then started for the United States, with many more Americans than could be accommodated in the cabins. In spite of their losses, the passengers were a fairly cheerful and very sociable group and we had some of the best concerts I have ever heard on shipboard.

We were the first to arrive in America after the earthquake, and nothing could exceed the kind treatment we received, according to our needs. The Siberian collections were all saved, those left on the *Empress* coming on later, without the slightest difficulty with either the customs officials or the shipping agents. They are now for the most part in the U. S. National Museum and are in process of being described.

Japan is a land in which the old is strangely mingled with the new. May she contrive to keep her great and striking virtues, while assimilating what is best in modern science and culture. When coming out on the *Taiyo Maru*, we were charmed by a little Japanese child, Hisa Takata, and I was moved to write the following verses, which were printed on the ship and distributed to all the passengers. After having been in Japan, I do not think I can better express my feeling about the country.

PUELLA JAPONICA

I had a dream of old Japan, of ages long ago,
The glory of the sunrise land, the soft and mellow glow
Of light upon the mystic glades where dwelt the maidens fair,
The perfume of the peonies upon the summer air.

And can we then recall the past, and make it live again,
Forget the turmoil and the strife, forget the grief and pain,
And dream that all the world is young, and all the earth is gay,
As hand in hand our fellows walk along the golden way?

It is no dream, I see again the beauty of the past,
The very soul and essence of the old Japan at last,
All concentrated in a maid as tiny as may be,
And full of charms to win the hearts of all who chance to see.

And yet it is the future that the past has made for us,
The olden time will not return, but build the new, and thus
Our maiden takes her heritage, her power of mind and heart,
To help to make the new Japan, of which she is a part.

THE PHYSICAL BASIS OF DISEASE

IX. THE TREATMENT OF DISEASE

By THE RESEARCH WORKER

STANFORD UNIVERSITY

"ONE or two lumps?" asked "the wife" as they made themselves comfortable in the manufacturer's sitting room on the fifth floor of the St. Francis.

"Three," replied the research worker.

"If diagnosis is so often wrong," said the manufacturer, "treatment must often be pure humbug."

"We mustn't judge religio-therapists too harshly," said the research worker. "A diagnosis is not necessary from their point of view. To them all disease is but manifestation of divine displeasure. All disease to be treated by some form of religious observance.

"Their error in diagnosis, however, is a serious matter in judging the alleged results of their treatment. When Christian Scientists publish hundreds of alleged cancer cures, with not an authentic case of cancer among them, hundreds of alleged cures of tuberculosis with not a single authentic cure to be found by impartial investigators, it is a serious matter."

"Haven't they any real cures to their credit?" asked the wife.

"Yes. Alleged cures by religious methods have been carefully studied by impartial investigators, interested only in determining the truth. Also, by official boards composed of priests, clergymen, physicians and laymen. Authentic cures have been found. But these are all cures of subjective symptoms. Of psychical or hysterical forms of disease. Of the psychical accompaniments of organic disease. No direct curative effects in organic disease have been found. Only indirect effects through improvement in psychical condition. Courage, hope, absence of worry, focusing of interest."

"But the miraculous cures of the Bible?" insisted the wife.

"One of the miracles was the changing of water into wine. But no religious cult ever advocated the substitution of prayer and faith for the grape industry of California.

"Do you realize religio-therapy is the oldest form of medical treatment? Tried from earliest times. All religions. All conceivable forms. If religio-therapy were able to deliver the goods,

would it have been abandoned by the medical profession centuries ago?"

"Pretty hard on the Catholic church," said the manufacturer. "They teach the religious cure of disease."

"You're mistaken."

"But we're constantly up against it," insisted the manufacturer. "Large Catholic element in our Pittsburgh plant. 'Most every day Miss Harrison, our social worker, reports wives and children treated solely with holy water. Even though medical treatment is free to employees.'

"The ignorant Catholic still preserves medieval superstitions. Cure of organic disease by holy symbols. This is not the belief, however, of intelligent Catholics. Nor is it part of the prescribed articles of faith. Witness the Catholic hospitals and nursing sisterhoods in all parts of the world. The Mayo Clinic.

"The illiterate Catholic, however, with his reliance on holy symbols, is a serious menace. The main cause of the high death-rate in Catholic countries. He is not, however, as serious a menace as his Protestant equivalent. The Catholic church is not in politics along medical and hygienic lines. Look at the governor of California refusing to endorse modern hygienic measures for fear of alienating the Christian Science vote. The regents of our state university denying adequate appropriations to the medical department for fear of antagonizing the Protestant religio-therapeutic bloc."

2

"Religio-therapy shows itself, not only in treatment by ritual and holy signs, but in treatment by material agents. The pharmacopeia of the middle ages was largely religio-therapy. Foul-smelling, evil-tasting concoctions to make the interior of the body an unpleasant dwelling place for invading demons. Heart-shaped, kidney-shaped, liver-shaped leaves, believed thus divinely marked for the cure of human disease.

"Probably the outstanding modern example of religio-therapeutic pharmacopeia is homeopathy. Rapidly disappearing. Practically extinct in most parts of the country. Homeopathy was based on the conscious or subconscious religious hunch that Divine Providence had placed on earth material agents for the cure of all human ills. That He had clearly marked these agents for man's recognition. About the only way we can conceive material agents thus marked is by their power to produce symptoms. An agent divinely marked to cure headache would thus cause headache if given in excessive doses. One set aside by Deity to cure nausea would produce vomiting.

"The early homeopaths found a number of material substances apparently confirming this hunch. Nitroglycerine, for example. One of the outstanding symptoms of nitroglycerine poisoning is intense headache. Queer as it may seem, nitroglycerine in small doses often relieves headache.

"Good evidence there's something in their belief," said the manufacturer.

"At the time homeopathy was founded, the biological action of drugs was not understood. Drugs were prescribed mainly because experience had shown their usefulness.

"The outstanding effect of nitroglycerine in experimental animals is to lower blood pressure. Headaches are of two classes—high blood pressure headaches; low blood pressure headaches. Nitroglycerine, given to a patient with high blood pressure headache, may reduce the blood pressure to normal and give relief. Given to a low blood pressure headache it still further decreases blood pressure and aggravates the symptoms. Nitroglycerine, therefore, is not a divinely marked cure for all headaches. A material agent for lowering blood pressure.

"But I know several successful homeops," said the manufacturer.

"I doubt if there is a physician of standing now practicing homeopathy as originally conceived. Most of them have adopted modern methods. Homeopaths in name only. Their schools and hospitals have practically disappeared in most parts of the country."

3

"Study of the biological action of nitroglycerine is typical of the experimental studies that have laid the foundation for modern therapeutics. Traditional remedies have been tested on experimental animals. Careful clinical evidence collected.

"This study has been most discouraging. Numerous time-honored drugs have been shown to be valueless except for their psychical appeal. Take sarsaparilla. A venerable remedy. Believed to have mysterious beneficial effects on nutrition. Wide reputation as a cure for syphilis. Sarsaparilla was shown by animal experiment and clinical evidence to be practically inert. It has virtually disappeared from modern medicine. Still retained, however, in folk medicine. Still the subject of profitable commercial exploitation.

"Other venerable concoctions have been shown to owe their sole virtue to some simple component, such as alkali. Ninety-eight per cent. of the traditional remedies have been thrown overboard. But two per cent. found to have biological effects, useful in the

treatment of disease. Most of the ancient remedies originated long before physicians had more than the crudest ideas of anatomy. Before the functions of organs were known. Before the microscope had revealed the structural changes in disease. It's a wonder even two per cent. of these remedies survived.

"Treatment based on knowledge of the biological action of drugs is not the simple process of our forefathers. They administered drugs largely for their alleged curative effects, active against all disease. To them, accurate diagnosis was not necessary. In contrast, modern scientific therapy necessitates an accurate determination of the biological abnormalities in the patient. Abnormalities to be corrected by therapeutic agents."

"The end of quacks," said the manufacturer.

"As soon as the public is convinced that modern science can deliver the goods. Except with cathartics, whose action is understood, belief in mysterious curative forces is almost universal. The dear old lady who during her husband's illness took daily doses of his medicines, to store up in her body curative powers for a time of need, is typical of the usual point of view. Even with people otherwise well informed.

"The contrast between modern therapy and medieval methods is well illustrated by any ancient remedy that has survived modern research. Iron, for example. Used since earliest times. Introduced solely because iron, the strongest metal, was believed to carry the spirit of strength into the body. Unlike most drugs introduced for similar reasons iron preparations were actually found to increase physical strength in an appreciable number of cases.

"Biological research has shown that iron is a necessary food. All animals, all plants. Without iron normal growth, even life is impossible. In higher animals, iron exists mainly as coloring matter in the blood. This red iron compound is the main agent for the transportation of oxygen to vital organs. In conditions of iron starvation, or in iron reduction from other causes, muscular weakness and other distressing symptoms of oxygen hunger are experienced. The administration of iron in such cases enables the body to raise its iron content to normal. The unpleasant symptoms disappear. Not a magic, strength-giving drug, correcting to all forms of human weakness. A normal food, effective only against weakness due to low iron percentage in the body. Given to normal individuals the excessive iron is not stored up in appreciable amounts. Thrown out in the excretions."

"Safely prescribed in all diseases," said the manufacturer.
"A cure if you strike the right disease."

"Iron in various forms is an almost ideal drug for commercial exploitation. Scores of iron preparations have been put on the

market. Long lists of diseases the preparations are alleged to cure. Testimonies from impressed neurotics. Occasional individuals with iron-starvation miraculously restored to health. A cent's worth of iron, a pint of colored water, a penny bottle, a two-cent carton. Sold to druggist for twenty-five dollars a gross. Forty million bottles at a dollar a bottle worked off on the credulous public. Tempting profits."

"Probably think the suckers will throw away their money anyway," said the manufacturer.

"The financial side is of no consequence. What is important, however, is the resulting loss of human life and efficiency. Thousands of beginning cancers reaching an inoperable stage, while the fools take commercialized iron. Tens of thousands of cases of beginning tuberculosis. Venereal disease. Bright's disease. Heart disease."

4

"Probably a better conception of scientific therapy is obtained from some new drug that has resulted from modern biological research. Adrenalin, for example. A chemical product, isolated from the adrenal glands of animals. Later successfully synthesized in the chemical laboratory.

"Adrenalin causes numerous biological reactions. The outstanding reaction is marked constriction or narrowing of the blood vessels. Applied to a cut surface it causes the blood vessels to shut so completely that hemorrhage ceases. A valuable instrument in surgery, particularly in parts of the body where control of hemorrhage is difficult by other means. Injected subcutaneously, adrenalin is absorbed by the blood. Causes narrowing of the blood vessels in all parts of the body. Thus increases blood pressure. A valuable agent in heart failure, shock and other conditions in which the blood pressure is so low as to endanger life. So spectacular are some of the results obtained with adrenalin that newspaper accounts are constantly appearing of corpses miraculously restored to life by its use. Not a drug with mysterious curative powers. A chemical agent with definite biological effects which may be used to counterbalance known biological abnormalities in disease.

"Nitroglycerine with its power of decreasing blood pressure, adrenalin with the property of increasing blood pressure are typical of the therapeutic agents of scientific medicine. Drugs have been found with which the action of many of the vital organs may be varied at will. Strychnine increasing peristaltic movements in the intestines. Morphine decreasing them. Atropine hastening the heart. Digitalis slowing it. Iodides increasing bronchial secretion.

Benzoic acid decreasing it. Caffeine increasing urinary output. Not agents with mysterious curative powers. Agents producing definite biological reactions. Intelligently used they may counteract the effects of disease, relieve symptoms. Indirectly assist the body in its efforts at readjustment and repair.

"In addition to these physiological aids, a number of direct curative agents have been found. Quinine, a toxic substance which kills all forms of animal life, can be tolerated by the human body in sufficient doses to kill the invading germs of malaria. Salvarsan tolerated in doses sufficient to free the body of syphilis. Antitoxic serum administered in sufficient amounts to neutralize poisonous products absorbed from a diphtheritic throat."

"I see that Dr. H—— has been acquitted," said the wife.

"H—— was tried solely for his criminal responsibility under present laws for failure to give antitoxic serum. Nineteen chances out of twenty the life of his diphtheria patient would have been saved by this serum. A nineteen-to-one bet that he was responsible for the death of the child. A legally qualified physician. Hopelessly ignorant of modern biological science. H—— stated under oath that in his opinion serum is valueless. That the only cure for diphtheria is vinegar. Assuming this to be his honest opinion, he was not criminally liable under present laws. Not H——, but the present legal code was at the bar in this trial."

"If salvarsan frees the body from syphilis," said the manufacturer, "I should think substances might easily be found to free the body from tuberculosis."

"Tuberculosis and syphilis are quite different. The germ of syphilis is a very delicate microorganism. A few minutes drying renders a syphilitic discharge harmless. The mildest antiseptics sterilize it. In contrast, tuberculous sputum can be dried for weeks without losing its power to produce disease. Resists antiseptics that will kill human tissues. I am doubtful if tuberculosis can ever be mastered by this method. Commercialized products with alleged powers to free the body from tuberculosis, however, find ready sale."

5

"Biological research has not only given a rational basis for the use of drugs, but a rational understanding of drugless methods. Electricity, baths, exercises, massage. All studied for their physiological effects. Their value or lack of value determined."

"One of our Pittsburgh hospitals has been soliciting contributions for radium," said the manufacturer.

"If it's a high grade hospital, you can safely contribute. Probably want radium for a serious purpose, not a mere advertising stunt. In the hands of competent men radium is apparently a

valuable adjunct in the surgical treatment of cancer. Extravagant, unwarranted claims have been made for it, however. A source of danger in the hands of incompetent and unscrupulous, who substitute radium for older surgical methods. Numerous quack radium institutes. Fake radium specifies."

"Is there any scientific foundation for osteopathy?" asked the wife. "I haven't tried that yet."

"One of the outstanding superstitions of the middle ages was the belief in the curative effects of laying on of hands. Mysterious curative spirits believed transferred by this method. Reigning monarchs set aside certain days for such treatment. Miraculous cures reported. In time it was realized by the better informed that the only virtue in such treatment was its psychical appeal. The practice was discontinued.

"Belief in the efficacy of laying on of hands, however, remained with the ignorant. Sufficient for profitable exploitation. Exploitation was often clothed in pseudo-scientific terms. Alleged transference of 'animal magnetism,' 'vital electricity,' 'biological emanations.' With the growth of popular knowledge of electricity, the public no longer fell for this. Recent exploitations have based their claims on alleged curative reactions set up in the patient's own tissues. Stimulation of nerve trunks by pressure or friction. Osteopathy is but a modern survival of medieval laying on of hands. Abandoned by the medical profession centuries ago. No curative value except that of ordinary massage plus psychical appeal."

"But osteops claim they know more about nerve physiology than regular physicians," insisted the wife.

"Twenty-five years ago I was offered the professorship of physiology in the leading osteopathic school of this country. They'd obtained my name from a Chicago teacher's agency. At the time I was wholly untrained in medical subjects except a six weeks' summer course in college physiology. In their eyes this fitted me to pose as their final authority in nerve physiology. With knowledge far in advance of biologists who had spent a life-time in neurological research."

6

"Deplorable condition," said the manufacturer. "What's the answer?"

"But one remedy. Popular education. The physical basis of disease. A course in elementary pathology in every high school."

"I should think a better attack would be through the churches," said the manufacturer. "From the facts you've cited any lawyer could make out a pretty good case against the churches as enemies of modern civilization."

"No physician would take that view. It's quite evident, however, that the churches have often been wrong in their conception of the relation of Deity to the human body. The Christian Deity has evidently set man the task of mastering, dominating the biological forces of the body, as He has set the task of gaining dominion over other material forces in nature.

"Above the portals of a big research institute there is engraved the following legend. South African, I believe:

"¶ In the Year of the Great Winds, Ah-e-gish, Father of All Gods, descended upon Earth. ¶ And the People cried out: Ah-e-gish, Ah-e-gish! Help us, lest we Perish. ¶ Then spake Ah-e-gish: ¶ In the Earth, and in the Fruits of the Earth, have I placed all things Necessary. Find them and be as Gods. ¶ Thus speaking, Ah-e-gish ascended into the Heavens.

"How about legal control?" asked the manufacturer.

"Ineffective. At least, so long as medical and hygienic matters are in the hands of political machines, reflecting the ideas of the ignorant. Not the wishes of the intelligent minority. Easily worked by charlatans. Bribed by commercial agents. If the making and enforcement of medical and hygienic laws could only be intrusted to a courageous, intelligent, non-partisan board. Economists. Hygienists."

"They'd hang California's ten thousand quacks," said the manufacturer.

"I'm not certain they'd pay much attention at first to irregular practitioners. They'd attack the more important problem. Elimination of incompetents and unscrupulous from the regular medical profession. Raise the profession to the honor and dignity the majority of its members so richly deserve.

"Do you realize a third of the regularly licensed physicians of California are incompetent? Half, in some states. The war was a great show-down for the medical profession. Thousands of legally qualified physicians. Representative men. Drawn from all parts of the country. Seventy-five per cent. of them so incompetent that they could be used only after months of additional training. Thirty-five per cent. so deficient that it was useless to attempt their training. Quietly discharged. Assigned to clerical duties.

"I'm revealing no secret. The matter was aired at the time in official bulletins. Subject of editorial comment in leading medical journals.

"Heavens!" added the research worker, glancing at his watch. "Twelve minutes to catch the last suburban express."

"I've my car at the curb," said the manufacturer. "Get you to the station in five minutes."

THE STATE OF SCIENCE IN 1924

HELIUM GAS AND ITS USES

By Professor J. C. McLENNAN, F.R.S.

DISCOVERY OF HELIUM

IN the history of science there is no more remarkable example of the development of purely scientific research into industrial application than is afforded by helium. No element has a more romantic history and none is of greater interest to men of science or more likely to prove of practical importance. The gas was discovered on the sun twenty-seven years before it was found on the earth. It is one of the chief constituents of the great flames or prominences which are continually being spurted out by the sun to heights of tens of thousands of miles, and are seen during total eclipses of the sun. In October, 1868, Sir Norman Lockyer announced to the Royal Society that he had devised a means of observing these flames whenever the sun was shining, and that one of the luminous gases in them could not be identified. In his words, "we had to do with an element which we could not get in our laboratories, and therefore I took upon myself the responsibility of coining the word *helium*."

TERRESTRIAL SOURCES OF HELIUM

In 1895, Sir William Ramsay, in connection with investigations of the element argon, discovered by Lord Rayleigh and himself in the earth's atmosphere, extracted a small quantity of gas from the mineral cleveite, and upon examining it found that it contained helium in addition to argon. Investigations have since shown that helium is widely diffused throughout the earth. It can be obtained from many types of rocks and minerals and is present in varying amounts in practically all natural gases and spring waters. It also occurs in the atmosphere in the proportion of about four parts to one million by volume. It has been proved to be formed by the disintegration of radium and other radioactive elements, and the α -particles shot out by these elements with velocities of about 12,000 miles per second are actually atoms of helium. Sir Ernest Rutherford has succeeded in converting a certain amount of nitrogen gas into hydrogen by bombarding the gas with the nuclei of helium atoms in the form of α -rays.

SOME PROPERTIES OF HELIUM

Next to hydrogen, helium is the lightest gas known. It is both non-inflammable and non-explosive and possesses 92 per cent. of the lifting power of hydrogen, so that it is a most suitable filling for airship envelopes. For aeronautical purposes, hydrogen can be mixed with helium to the extent of 15 per cent.; the mixture will no longer be inflammable or explosive in air. By the use of helium, the engines of airships can be placed within the gas envelope if desired. A further advantage of helium over hydrogen is that the buoyancy can be increased at will by heating or cooling the gas by electric or other means. Moreover, the loss of gas from diffusion through the envelope is less with helium than with hydrogen by about 30 per cent.

Helium can be used to fill thermionic amplifying valves for use in wireless telephony and also for filling incandescent filament lamps and arc lamps.

The lowest temperature yet attained on the earth was reached by Professor Kamerlingh Onnes, of Leiden, in 1908, by liquefying helium. The temperature was 490° F. below the freezing point of water, and was within 2 or 3° F. of absolute zero. It was found by Professor Onnes that a number of metals possessed a remarkable "super conductivity" at this temperature. Mercury, in particular, at the temperature of liquid helium, conducts an electric current ten millions times more easily than at ordinary room temperatures, and current started by induction in a coil of lead wire at the temperature of liquid helium maintained their intensity for more than an hour with but little diminution in strength. By the use of helium, therefore, not only has one element been changed into another, but the nearest approach to perpetual motion has been found.

HELIUM IN NATURAL GASES

In 1915 Sir Richard Threlfall suggested that an inquiry into the helium content of supplies of natural gases within the Empire from the point of view of their development for aeronautical purposes should be carried out. The United States took up the subject when America entered the war two years later. A survey of all the natural gases within the Empire made by the writer and his associates showed that those from Ontario and Alberta, Canada, were richest in helium, though the proportion was relatively low, being about one third per cent. of the natural gases. The supply from sources in Great Britain is almost negligible, the natural gas at Heathfield, Sussex, having a helium content of only one fifth per cent., and that from the King Spring, Bath, of one sixth per cent.

No natural gas within the Empire has been found to contain as much as one half per cent. of helium, whereas in the western states of America, especially in Texas, natural gases exist which contain from one to two per cent. of helium, and some springs in France have as much as five per cent.

From 30,000 to 40,000 cubic feet of helium gas are now being extracted daily from natural gas in the United States. The gas is being compressed in steel cylinders and stored for use in airships and for other purposes, and its export is prohibited by law. Until the spring of 1918 not more than about 100 cubic feet of helium had ever been collected, and its market price was about £300 per cubic foot; since then, nearly three million cubic feet of the gas have been produced in the United States for use in the U. S. Army and Navy, and their new airships of the rigid type are being inflated with helium instead of hydrogen.

From ten to twelve million cubic feet of helium could, however, be obtained annually from natural gases in Canada, and the gas has such direct bearing upon problems of scientific and practical importance that the governments of Great Britain and Canada might, even from the point of view of national safety, legitimately be asked to follow the example of the United States and operate the plant which was constructed during the war and operated for a time at Calgary. With this plant it was shown that helium of high purity could be produced at less than five pence a cubic foot.

LOW TEMPERATURE RESEARCH

Much of our knowledge of low-temperature effects we owe to the brilliant work of such distinguished men as Andrews, Davy, Faraday and Dewar. The discovery of the rare gases helium, neon, argon, krypton and xenon we owe to Lockyer, Rayleigh, Ramsay and Dewar. A fitting memorial to the work of these great men would be a laboratory for the purpose of making still further progress in the field of low-temperature research—a field in which British men of science have made such brilliant and notable advances. With suggestions received from Professor Kamerlingh Onnes, of Leiden, and with financial assistance received from the Honorary Advisory Council for Scientific and Industrial Research, of Canada, the Carnegie Foundation for Research and the University of Toronto, such a laboratory containing a magnificent cryogenic equipment has come into being in the Physical Laboratory of the University of Toronto. With it large supplies of liquid air, liquid hydrogen and liquid helium can be obtained.

This cryogenic laboratory was opened on January 10, 1923, and on that occasion demonstrations were given of the production of

liquid air, liquid hydrogen and liquid helium in quantity. It is hoped that the facilities of this laboratory will be used to the fullest extent by workers in low-temperature research.

THE PRINCIPLES OF FINE MEASUREMENT

By J. E. SEARS

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THE term "fine measurement" may be employed, even in relation to simple determinations of dimensions, in two or three different senses. It may refer to (1) the ascertainment—not necessarily with great proportional accuracy—of the sizes of extremely minute objects or of very small displacements; (2) the measurement of very small differences in dimension between objects of more considerable size; or (3) the determination, with the highest possible degree of precision, of the absolute sizes of various objects in terms of one of the recognized standard units of length. It is the object of the present article to deal with measurements of the second and third classes, of which the third presents, intrinsically, much the more difficult problem. However, by suitably arranging the work, measurements of the third kind can be obtained in many cases by calculation from observations of the second kind, and advantage should be taken of this simplification wherever possible.

STANDARDS

Whatever the nature of the measurement to be undertaken, the object, essentially, is the determination of some dimension in terms of the reference standard, and the nature of this standard calls first for consideration. The principal primary standards of length in use at the present day are the British Imperial Yard and the International Meter. Both these units of length are purely arbitrary, being each defined as the distance, at a certain specified temperature, between the centers of two fine lines scribed on small polished areas in the neutral plane of the cross-section of a material bar which is used as the ultimate representation of the unit. The British Imperial Yard is laid down on a bar of Baily's metal (copper 16, tin $2\frac{1}{2}$, zinc 1) 38 inches long by one inch square, the graduation marks being on gold studs let in to the bottom surfaces of two circular pits, one half inch in diameter and one half inch deep, one inch from either end of the bar. The standard temperature is 62° F. The International Meter is laid down on a bar of

platinum-iridium (platinum 90 per cent., iridium 10 per cent.) of X-shaped cross-section, the neutral axis being exposed throughout its length. Its standard temperature is 0° C.

The graduation marks are arranged in the neutral plane of the bar in order that the distance between them may not be affected by the compression or extension which may occur in the upper or lower fibers of the bar owing to the mode of distribution of its weight upon its supports. The supports are so arranged as best to minimize the effects of the flexure of the bar in respect of the difference between the free, unstressed form of the neutral plane, and the slightly curved shape which it assumes when the bar is resting on the supports under the action of its own weight. In the case of the British Imperial Yard, the supports consist of a series of eight equally spaced rollers, interconnected by a system of levers in such a manner that each roller takes an equal share of the weight. In the case of the International Meter two rollers only are used, spaced in such a manner that the distance between the graduation marks on the bar is at its maximum possible value, with the result that small errors in setting of the rollers have negligible effect on the measurements.

Each of these bars being of metal, their lengths vary with changes of temperature. The length of the bronze yard bar increases by about 10 parts in a million for each 1° F. rise in temperature, and that of the platinum-iridium meter bar by about 8 parts in a million for each 1° C. It is therefore of the greatest importance in the employment of these standards to ensure that their defining lengths are observed at exactly the right temperatures. Similar remarks, of course, apply to the objects to be compared with them, and where very precise measurements are concerned, the problem of accurate temperature control frequently represents one of the principal difficulties to be overcome.

MECHANICAL COMPARISON OF LINE STANDARDS

In comparing the lengths of two standard bars it is usual to set them up side by side on rollers supported on two independent girders contained in a water bath mounted on a carriage, which is capable of being moved in a direction perpendicular to the length of the bars. The graduation lines are observed by means of a pair of microscopes rigidly supported in such a manner as to be unaffected by the movement of the carriage, focussing being done by adjusting the positions of the girders on which the bars are supported. The water in the bath is well stirred, and the temperature of the bars is ascertained by means of thermometers placed in the water with them. An electrical thermostatic device is used to

maintain the water at the desired temperature. By the movement of the carriage first one bar and then the other is brought into view, and the positions of the graduation marks are read off by means of cross-wires contained in the micrometer eyepieces of the microscopes. The differences between the observed readings, duly corrected for the known errors of calibration of the thermometers and microscopes, and for the coefficients of thermal expansion of the bars if the temperature has not been exactly adjusted, give finally the value of the difference in length between the latter. In some cases, where it is not possible to immerse the bars in water, the whole room containing the apparatus has to be thermostatically controlled and the apparatus itself very elaborately screened to protect the bars from the effects of the body heat of the observers.

Great precautions have also to be observed in order to eliminate various possible sources of error. The two bars are observed alternately several times in succession, and the observations must be so arranged in respect of time that the mean epoch of observation is the same for each bar, and also for the thermometers. Otherwise, any gradual change of temperature taking place during the course of the observations may affect the results. The bars must be reversed end for end in turn, and interchanged upon the girders, all the observations being repeated in each configuration, or slight differences of appearance of the lines under the microscope or changes in distribution of weight may have an effect. Each observer must take an equal number of observations of each end of each bar under each microscope, or the personal asymmetry of the observers' sight may have an influence, and, unless the cross-lines in the two microscopes are equally thick and equally spaced, the effects of personal error will not be fully eliminated unless each observer finally repeats all his observations viewing from the back of the apparatus instead of the front, so that the appearance in the microscope is changed from right to left.

In many cases, if the two standards or objects to be compared are known to have the same coefficient of expansion, the problem of temperature control can be greatly simplified, as it is then only necessary to ensure that both are brought to the *same* temperature, without the necessity of knowing exactly what that temperature is. A particular case where this is readily and automatically secured is in the operation of determining the values of the subdivisions of a graduated metal scale in terms of its whole length. For this purpose a comparator is employed in which the carriage can be traversed in the direction of the length of the bar. Two microscopes are used, as before, fixed at a distance apart corre-

sponding to one of the subdivisions it is desired to determine. Readings are taken on the graduation marks defining this subdivision, and the bar is then moved along until the next nominally equal subdivision comes into the field, and its graduation marks are similarly observed, the operation being repeated until all the nominally equal subdivisions have been compared with each other. In this way, for example, the values of all the decimeter intervals of a meter bar can be determined in terms of its total length. The bar being a single piece of metal, it may reasonably be assumed that each portion of it has the same composition and coefficient of expansion, and also, since it is a good thermal conductor, that the temperature throughout its length is uniform at any given moment. So long, therefore, as the rate of change of temperature is small and steady, if the observations are properly arranged so that the mean epoch of reading each subdivisional interval is the same, errors in measurement due to temperature are entirely eliminated. The operation also illustrates well the advantage of always comparing dimensions nominally equal, since only the small differences have actually to be measured, and errors of calibration of the microscopes are therefore of little effect.

CONSTANCY OF STANDARDS

Another very important consideration is the actual constancy in length of the material standards themselves, in respect of time. Variations may occur due either to actual molecular changes in the substance of the bars or to minute damage done to the defining lines in the periodical cleaning which is inevitable, no matter how carefully the bars are kept. There is evidence that the present British Imperial Yard has probably shortened to the extent of about two ten thousandths of an inch from the former cause in the 80 years since it was constructed, while it has recently been ascertained that the two working copies of the International Meter, used at the Bureau International des Poids et Mesures at Sèvres to control other copies, have changed about 0.0004 mm in the last thirty years—probably from the latter cause. There is also the risk of damage due to shock in transport. A nickel copy of the meter used at the National Physical Laboratory, which had been quite stable for some fifteen years, was recently discovered to have changed about 0.0005 mm after being sent to Sèvres for reverification, though, so far as is known, every precaution was taken to avoid accident.

With all these difficulties in mind, it is natural to seek for some alternative type of standard, for preference a natural standard re-

producible at will in any national laboratory, and a possible standard of this kind is to be found in the wave-length of light. Professor A. A. Michelson by one method, and MM. Fabry and Perot by another method, some fourteen years later, determined the number of wave-lengths of certain lines in the cadmium spectrum in terms of the international meter, and obtained remarkably concordant results; and at the last meeting of the International Committee on Weights and Measures (Metric) a resolution was adopted accepting in principle the eventual adoption of the wave-length as the ultimate reference standard of length so soon as the best conditions for reproduction of uniform sources of light waves, and the best mode of applying them for the purpose, should have been fully investigated and determined. This work is now being undertaken in the various national laboratories. It is not, of course, an easy problem, as many conditions—*e.g.*, those of the atmosphere through which the light-waves pass during measurement—have to be standardized, or the effects of their variations allowed for, before uniform results can be obtained.

END-STANDARDS

Before practical use can be made of a light-wave standard for purposes of everyday measurement, it has, of course, to be compared with some material standard suitable for use in the ordinary mechanical processes of measurement. For such work two kinds of standard, line-standards such as we have already been considering, and end-standards, defined by the distance separating two parallel flat terminal faces, are required. For most purposes of engineering measurement the latter are the more important, and at present they have to be derived from the former—one of the most difficult operations in metrology. Wave-length measurements, however, are conducted by observing the distance between two plane parallel optical surfaces by means of the mutual interference of light rays reflected at them, so that, provided an end-standard of sufficient perfection can be produced, it is evidently more convenient to use such a standard, rather than a line-standard, as the primary material representation of the length unit derived from the wave-length.

Recently a great improvement in the perfection of finish of plane parallel end-standards has been achieved at the National Physical Laboratory by Mr. A. J. C. Brookes, who has succeeded in producing cylindrical standards of a yard or meter in length, the ends of which are polished flat, parallel and square with the axis of the cylinder to within a few millionths of an inch over the

whole area of faces, one inch in diameter. The introduction of these very refined gauges is likely to facilitate the adoption of the wave-length standard.

The mechanical comparison of such gauges, once the principal standard has been derived from the wave-length, can be carried out to a very high degree of accuracy by means of the tilting level comparator, devised by Messrs. Brookes and Sears. The two gauges to be compared are set up side by side on a horizontal turntable, with their axes vertical, and a sensitive level, carried on two ball feet, is allowed to rest upon their upper faces. The indication of the bubble is noted and the level removed. The turntable is rotated through 180° , so as to interchange the position of the two gauges beneath the level, which is then allowed to rest upon them once more, and a second reading of the bubble is taken. The difference between the two readings gives the measure of the difference of length between the two gauges.

The finish of the end faces of these gauges is so perfect that two or more of them will "wring" together, in the manner of the now well-known Johansson gauges, to form a composite gauge, and to obtain the lengths of shorter gauges of the same type in terms of the yard or meter, different combinations of nominally equal total length are wrung together and compared in the above way. Here again only small differences are ever measured, and the arrangement of the apparatus is such that the groups being compared can easily be brought to the same common temperature, and are never handled during the measurements, so that, provided all the pieces are made of steel of similar quality, and their coefficients of expansion hence equal, the temperature difficulty is overcome.

OPTICAL INTERFERENCE METHOD OF COMPARISON

Shorter gauges, with flat parallel end surfaces and "wringing" quality of finish, were first introduced by the Swedish firm of Johansson, and are now being made in England by the Pitter Gauge & Precision Tool Company by a patented process developed at the National Physical Laboratory by Messrs. Sears and Brookes. Their calibration is effected on precisely the same principles as apply to the longer gauges, and may also be carried out on the tilting level comparator, the accuracy finally attainable in the standardization of a one inch gauge being of the order of 0.000001 inch. Alternatively it is possible to measure these gauges, and at the same time obtain a visual estimate of the degree of perfection of their surfaces, by the direct application of the principle of optical interference. If a glass plate with an optically worked flat surface be

placed close and nearly parallel to one of the surfaces of a gauge, and viewed in parallel light, a series of interference bands is seen which constitute, in effect, a contour map of the surface of the gauge, the spacing of the bands corresponding to successive intervals of about 0.00001 inch. If the opposite face of the gauge be wrung on to another optical flat, the interference pattern formed between the first optical flat and the surface of the gauge can be compared with that formed between the two optical flats, and by repeating this with light of different known wave-lengths and comparing the results it is possible to ascertain the exact length of the gauge in wave-lengths without any further measurement. This method can only be applied to short gauges, as the interference fringes are not seen unless the distances are small. Measurements can be effected by this method, also, to an accuracy of a millionth part of an inch.

PHOTO-ELASTIC COMPARATOR

A third method of measurement of the same high order of accuracy is by means of elastic strain, coupled with the use of an optical lever. Two machines operating on this principle have been made and are in use at the National Physical Laboratory. Both give a movement to a spot of light of about 0.3 inch for a change in length of 0.00001 inch. In one the gauge is measured between flat parallel anvils, as in an ordinary measuring machine, and in the other by point contact between three balls on one face and one on the other, this giving a geometric location. The essential feature of these machines is the complete elimination of all friction and backlash, such as is unavoidable with most types of mechanical indicators and with any screw-thread micrometer, where an oil film is interposed between the screw and the nut. The indication in these machines is an optically magnified image of the elastic displacement of a certain part which is deliberately made weak for the purpose, an initial mechanical magnification being afforded by means of a lever hinged elastically to the moving part. The rest of the machine is constructed with extreme rigidity, but its sensitivity is such that a relatively small pressure by the hand is sufficient to cause an appreciable movement of the indicating spot.

It is of interest to record that, with gauges of sufficiently perfect finish, it has been found possible not only to obtain calibrations consistent among themselves to a millionth part of an inch by these various methods, but also to secure agreement to this order of accuracy between measurements of the same gauges made in different countries. There is one point, however, in which the optical interference method differs from the mechanical contact

methods. In the former the length of any individual gauge is determined by means of reflection in its metallic surfaces. In the latter the length is ascertained by computation from the results of comparisons between a number of built-up groups of the same nominal total length. It has been found that the gauges will not wring together if perfectly dry, and that if too freely greased they will slide easily on each other. To obtain good wringing it is necessary to have a trace, but only a trace, of lubricant between the surfaces, and this lubricant forms a film which has a certain thickness. The nature of the operations is such that in the determinations made by mechanical contact, the resulting value of the length of any gauge is always associated with the thickness of one wringing film, which may be supposed to be distributed one half on either end. Since in the normal use of the gauges these films are actually present, the result so obtained is the actual effective length of the gauge. But it differs from the length found by optical interference to the extent of the thickness of one wringing film. It has been ascertained by comparing the results of mechanical and interference measurements of the same gauges that the thickness of a wringing film is reasonably constant, and varies from about one millionth of an inch when alcohol is used as a lubricant to three or four millionths when paraffin or vaseline is used.

STANDARDIZATION OF ENGINEERS' AND OTHER GAUGES

The flat parallel-ended gauges we have so far considered may be regarded as standard reference gauges for any desired dimensions. In the practical application of measurement, the objects, the sizes of which it is desired to ascertain, are usually of much more complicated form, and in their measurement it is generally necessary to make use also of other types of standard gauge; for example, cylindrical or spherical gauges. The sizes of these have first to be determined by comparison with the flat-ended gauges, and in these comparisons a new difficulty arises. The material—usually hardened steel—of which the gauges are made, is elastic, and when the gauges are placed under pressure between the faces of a measuring machine, their surfaces become deformed. With the flat-ended gauges, between flat parallel measuring faces, the pressure is distributed over a finite area, and the deformation is negligible, but with cylinders or spheres it is concentrated along the line or point of contact, and in this case it becomes appreciable. As an example, the total compression in the case of a steel sphere, one inch diameter, measured between plane parallel measuring faces under a load of two pounds, amounts to about 0.00005 inch—

this amount including also the indentation of the measuring faces. In comparing a sphere under these conditions with a known flat-ended gauge, a correction of this amount would have to be applied to the observed result.

A recent development in the art of fine measurement, introduced by the National Physical Laboratory during the war, is the optical projector, devised by Mr. E. M. Eden, and now made in two well-developed forms—the horizontal and vertical types. This consists essentially of a kind of magic lantern in which a beam of parallel light is directed on to the object to be examined, a magnified image of which is produced by means of a suitable lens upon a distant screen. The whole success of the apparatus depends, of course, on finding a lens combination capable of giving an undistorted image over the whole of a field of view of considerable area. This was Mr. Eden's achievement, and once accomplished it became possible to compare the shapes of profile gauges, screw gauges and other similar objects with accurately-drawn magnified diagrams of their normal outline. The apparatus was of the greatest value during the war in the verification of engineers' gauges for munition supplies.

More recently yet another application has been found for it in the examination of pantograph records of the profiles of objects otherwise inaccessible to direct optical inspection. To get a one to one reproduction, exact within one ten thousandth part of an inch, involves special design and extreme care in workmanship, but has been found to be not impossible, and an apparatus of the kind, designed and made in the metrology department of the National Physical Laboratory, is now in regular use for the measurement of gears. A ball at the tracing end is carefully traversed around the profile of a tooth, and a record is traced on smoked glass by a fine needle at the recording point. This trace is then projected on the screen at a magnification of 50 times, and it is found quite practicable to read off errors to an accuracy of one ten thousandth of an inch.

The applications of fine measurement to engineering problems of all kinds are, of course, almost unlimited, and it would be quite impossible in a brief sketch such as this to attempt to describe them in detail. A collection of typical instruments and methods is exhibited by the National Physical Laboratory in the Engineering Hall.

THE CIRCULATION OF THE ATMOSPHERE

By Sir NAPIER SHAW, F.R.S.

THE GENERAL CIRCULATION

RECENT progress in our comprehension of the circulation of the atmosphere derives largely from the law of relation between the velocity of air in steady motion and the distribution of pressure in any horizontal surface. If one looks through the meteorological literature of forty years ago one can scarcely fail to be impressed with the notion that the writers always had in mind the conditions of starting and stopping and thought little about the long stretches of the travel of the air. These stretches represent neither starting nor stopping, but steady or persistent motion under balanced forces, provided that we are permitted to include among the forces the effect of the rotation of the earth, which can be neither avoided nor ignored in any general atmospheric question. Yet it is no exaggeration to say that, with the motion of the atmosphere, starting and stopping are of no greater importance than they are in the passages of ocean-going steamers or non-stop trains.

We know that at the surface of the earth, from which most of our experience of weather is derived, there never is and never can be the steady motion which represents the balance between the gradient of pressure and the rotation of the earth, because the friction between the moving air and the earth or sea is always dissipating the energy of motion in eddies and ultimately in heat. To compensate for that loss and keep the motion steady, some force driving the air along its path would be required, but it is not forthcoming. However, in the free air above the surface at the height of a kilometer or two, say, 5,000 feet, we need not think any longer about the disturbances due to the surface, and there, provided we are not directly involved in the convolutions of a cyclone, we may rely upon what is called "the geostrophic wind," that is to say, a wind along the lines of equal pressure (isobars), with velocity inversely proportional to the distance between consecutive isobaric lines, as a valid normal representation of the actual wind.

The consequence of this recognition of a simple dynamical relation between undisturbed wind and pressure-distribution is that a "geostrophic scale" always lies on the modern meteorologist's working chart, and when he wants to know the effective wind, disregarding the surface-friction, he lays his geostrophic scale across his isobars and reads off the result in meters per second or miles per hour as he pleases, or as it pleased the person who made the scale.

USE OF PILOT BALLOONS

The general introduction of the use of pilot-balloons for determining the motion of the free air brings at one and the same time confirmation of the general principle and challenge of the individual facts. The assumption of the relation brings the winds of the upper air within the possibility of mathematical calculation in a manner which surprises all who take up the questions treated.

From this position, which is a very natural extension of Buys Ballot's law, it follows immediately that, if by any means we can determine the distribution of pressure at any level in the atmosphere, we can determine the horizontal velocity of the wind at that level by the simple process of laying a properly graduated scale across the isobars which represent the distribution of pressure; and the well-known barometric equation of Laplace gives us the means of calculating the pressure to be deducted from the value at the surface for any step of height when we know the temperature of the air at each level. Such a determination of pressure in the upper levels, without observations carried out on the spot *ad hoc*, may be regarded as being beyond the discretion of a cautious meteorologist when he is dealing with the distribution of pressure of to-day or yesterday, as represented on a "synchronous" chart of actual pressure and temperature at a definite epoch, with all the peculiarities of the meteorological situation and its local incidents; but it is not at all out of the question when we come to deal with average conditions representing the mean result of observations for an individual month extending over so long a series of years that the transient local conditions are merged in the general picture.

The reason for supposing that we can calculate the distribution of pressure at an upper level from the observed pressures at the surface, with sufficient accuracy for general purposes, is derived from an entirely unexpected result obtained from records of registering instruments sent up on balloons, known as "sounding balloons." They carry instruments but no passengers. Things are so arranged that after an upward journey of from 6 to 10 miles or even more they burst and come down with the instrument. They reach the earth with the instrument and its precious record undamaged within about two hours of the start and within a hundred miles or so of the starting point.

Records obtained in this way, in Europe to begin with, and then in America, over the Atlantic Ocean, the Greenland seas, the Antarctic, the Victoria Nyanza, the Dutch East Indies and Australia, disclose the remarkable fact that, provided the temperature

at the surface is the highest of the record, the rate of fall of temperature with height is the same in any part of the world. There are a good many occasions, particularly in the winter of the locality where the sounding is made, when the surface is colder than the air in the layers immediately above it, and then there is no satisfactory starting point for calculating pressure in the upper air. Even on these occasions the régime of the fall of temperature with height according to the numerical rule asserts itself when a certain height has been attained; but that does not help us in the calculation of pressures in the upper levels because the starting point at the surface is off the line by an altogether unknown amount.

Confining ourselves to summer temperatures, therefore, in which that difficulty does not arise, the pressures in the upper levels have been calculated with some assurance that we are at least within the range of probability, and on this basis the distribution of pressure over the northern hemisphere in July has been calculated for 2 km, 4 km, 6 km, 8 km and 10 km. The results are represented upon maps or models for the corresponding levels.

NORMAL ATMOSPHERIC CIRCULATION

Then we can use the distribution of pressure to calculate the normal atmospheric circulation at the surface and at the different levels. It is very complicated at the surface, but becomes much simplified at 2 km. At higher levels the régime is clear; it is a circulation from west to east round the pole, not quite along circles of latitude because there is some distortion of shape consequent upon the transitions from land areas to sea areas and vice versa. The circumpolar circulation, west to east, extends to about latitude 30° ; there it falls off very rapidly and along the equator and inter-tropical belt, there is a circulation in the opposite sense, from east to west.

The two circulations at any level are not altogether independent: there are limited regions along the latitude 30° around which apparently air may pass from the equatorial circulation to the polar circulation and vice versa. These localities seem to supply moving belts which carry, or gear with, the east to west circulation on the southern side and the west to east circulation on the northern side.

The final conclusion has been reached by Mr. A. W. Lee that, so far as the polar circulation is concerned, and apart from the local disturbances due to coast-lines, the successive layers of our atmosphere are rotating "like a solid." The west to east velocity represents a travel a little faster than that of the solid earth, the values of the angular velocities of the successive shells being 1.03ω at 4 km and 6 km, and 1.05ω at 8 km in July, where ω is the angular

velocity of rotation of the earth. The corresponding velocity for January, as determined from a chart of isobars by Teisserenc de Bort, is 1.08ω . The intertropical circulation from east to west at high levels has an angular velocity of 0.92ω , but at lower levels it is much less. These figures mean that a shell, from 4 km to 6 km high, makes a complete rotation with regard to the earth from west to east, in 33 days in summer and 12 days in winter. Another higher shell at 8 km takes only 20 days to complete a spin even in the summer. On the other hand, the higher air over the equator gets round the earth the opposite way in 12 days.

LOCAL DISTURBANCES OF THE CIRCULATION

This simple régime, so easily imagined and remembered, does not, however, reach the surface. There we find a complication which only a carefully constructed map can represent. If we seek for an explanation of that complication we must remember that, whereas during the day, when the surface is solarized, the layer of earth and sea is receiving heat from the sun, the opposite is the case at night, and long before night in the regions of long shadows. There the surface is losing heat, and as an inevitable consequence air runs down the shaded hills more and more as the shadows lengthen and deepen. How much air runs down and how fast it runs we do not know, but we know that the flow must be there and huge pools of cold air must accumulate in the lower levels. Moreover, the process is irreversible; cooled air must stick to the ground, warmed air can not. Hence we may regard the shadowed hills as pouring an immense volume of air on the lower regions, and thereby spoiling the simplicity of the distribution of pressure at the surface, and consequently that of the general circulation of the atmosphere in the lower layers.

There can scarcely be any question that the descent of cold air in this fashion expresses itself in the play of the general circulation as local modifications of the distribution of pressure at the surface and the formation of seasonal anticyclones. The converse process, the ascent of warm air, is another story and a much more complicated one. The descending air, which of necessity clings to the hillside, can always take advantage of the cooling of the ground, and is thereby helped all the way; it goes down headlong like an avalanche; but to climb, air has to leave the ground and make its way through the layers above with only the trifling assistance which it can obtain from the absorption of radiation by the water vapor which it carries. While rising, it is subject to the automatic reduction of its temperature consequent upon the reduction of its pressure, if no heat is supplied to it. It loses heat at the rate of

1° C. for 100 meters, while the temperature of the environment falls off with height generally only 1° C. for 200 meters. The transparent air through which we see the sun and stars looks perfectly similar and homogeneous, and is all called simply air; but it is really stratified by its temperature into layers which are quite impervious to air rising from below, unless the rising air has the temperature necessary to furnish the key to get through.

Facilis descensus Averni,
Noctes atque dies patet atra janua Ditis;
Sed revocare gradum superasque evadere ad auras,
Hoc opus hic labor est.

Yet the air as we know it manages it quite easily by an ingenious trick. It climbs to higher things on stepping-stones of its own dead water vapor. It loads itself with moisture. As it rises it cools, and, if it is fortunate enough to pass the dew point, it condenses part of its moisture and takes over the heat of vaporization previously latent, but now set free. Fortified therewith, it passes on its victorious way upwards, sometimes with a rush great enough to carry up huge hailstones, until it meets its match in an environment that has less lapse of temperature with height than the rising air itself, in spite of its propensity to appropriate the latent heat of its accompanying water.

Up to a height varying with latitude from some 8 kilometers at a pole to 17 kilometers at the equator, there is a layer of air called the "stratosphere," where there is no fall of temperature at all with height. That layer even the wettest atmosphere can never penetrate; it can not be overcome either by *opus* or by *labor*—it is just impossible and impassable.

However, in the "troposphere," the region that lies between the ground and the stratosphere, all kinds of enterprises are possible to rising air fortified with a sufficient supply of water vapor: Clouds, rain, hail, snow, thunder, lightning and nearly all the other incidents of weather.

These striking phenomena are most notable characteristics of those local disturbances of the general circulation which are called cyclones or cyclonic depressions. This has been recognized for a long time, and many meteorologists have thought that the cyclones really derived their energy from the convection of wet, warm air. Certain it is that if a rapid vertical ascent of air took place within the normal circulation, the circulation would be disturbed; the only question is by how much. It is also certain that if the layers of air in the middle atmosphere were traversed by air coming from below and passing out above, the rising air would carry with it from the middle layers more than its own mass, and the result of the eviction would necessarily be such a circulation as we may associate with

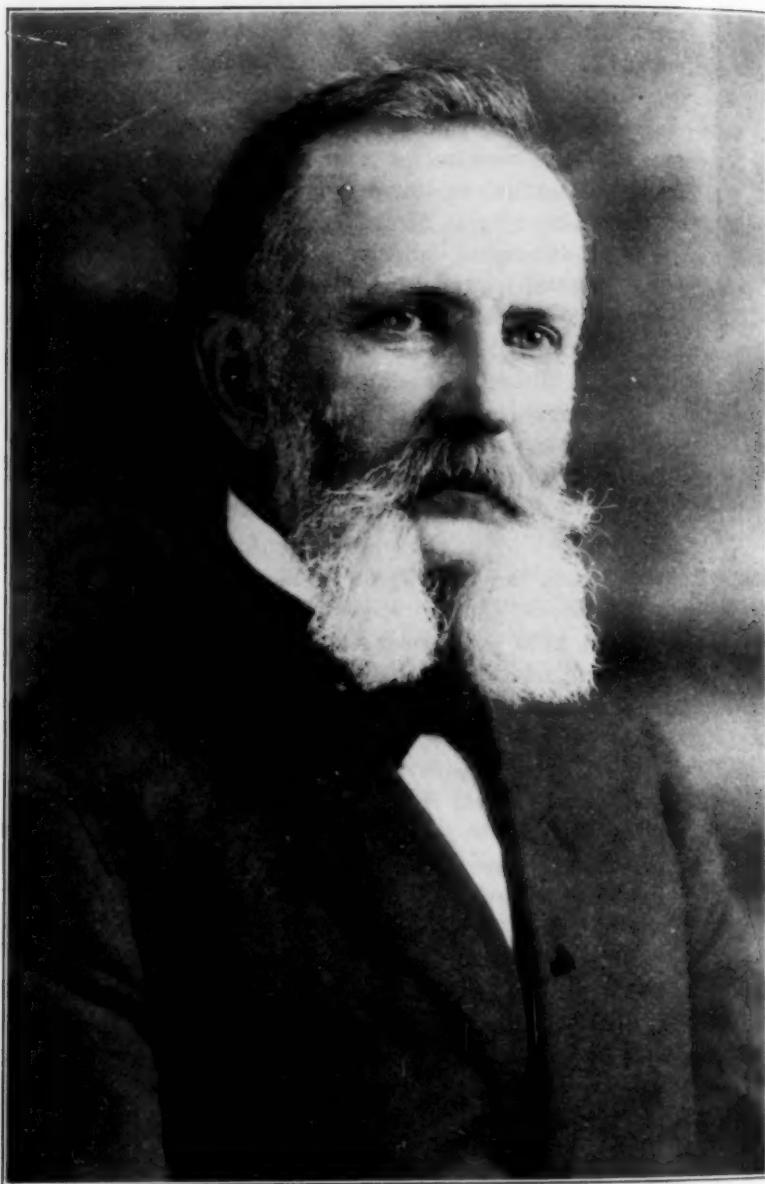
a cyclone freed from the friction of the surface. But, as yet, we can not speak with certainty as to the extent to which the origin or maintenance of the energy of a cyclone is due to the travel of air upward through the layers with the aid of the condensation of water vapor.

The new school of meteorologists in Norway traces the origin of cyclones to the mutual action of two currents of air across a surface of discontinuity and regards the accompanying weather as incidents of no dynamical importance, and a vortex as only the transient final form of wave-motion. On the other hand, a Japanese student of the Imperial College has recently shown that a vortex with its recognized distribution of pressure, traveling along at the height of a kilometer, would produce automatically in the layers near the surface all the phenomena upon which the Norwegian school bases its conclusions.

SYSTEMATIC UNITS OF MEASUREMENT

It is acknowledged by all, however, that the phenomena of the atmosphere represent the working of an exceedingly complex air-engine or steam-engine and that the ultimate explanation of the local disturbances, as of the normal circulation, must be looked for in the quantitative relationships of all the physical quantities inherent in the atmosphere. Gravity, heat, work, temperature, wind-velocity, solar radiation, terrestrial radiation, vapor-pressure, all are associated and all will have to be combined when the explanation comes to be worked out. If that be accepted, it is just as important for meteorologists to provide themselves with units of measurement on a systematic plan as it was fifty years ago for electrical workers. When we have to combine temperature with pressure in a formula, the measurement of temperature as a number of degrees from the freezing point of water has to be changed, whether the operator is aware of the fact or not. When we have to deal with the intricate relations of heat and work in the atmosphere to have to introduce a factor *A* or *J*, the very definition of which is uncertain, is adding to the inevitable *opus and labor*.

Hence one of the first steps in the explanation of the circulation of the atmosphere, when it comes to be written, will be the setting out of the measurements involved in systematic units; and therefore, as it will certainly be indispensable in the end when the work is done, so it will make things easier as the work proceeds. Thus we build our representation of the present state of knowledge of the circulation of the atmosphere and the means of extending it, upon the foundation of the representation of meteorological quantities in systematic units.



DR. WILLIAM F. HILLEBRAND

The distinguished analytical chemist, chief chemist of the United States Bureau of Standards, Washington, who died on February 7.

THE PROGRESS OF SCIENCE

By Dr. EDWIN E. SLOSSON

SCIENCE SERVICE, WASHINGTON

AMERICAN
BASEBALLS AND
GERMAN BOATS

MARK TWAIN counts as one of the great events in human history the moment when the idea shot through the brain of Howe "that for a hundred and twenty generations the eye had been bored through the wrong end of the needle."

Maybe some future author will count that moment equally momentous when the idea shot through the brain of Flettner that the smokestacks of an ocean vessel should not be used to carry off the smoke of the engine, for if they were revolved no engine would be needed. His experimental vessel, the *Buckau*, looks like an ordinary steamboat with two extraordinarily tall funnels. These are simply smooth cylinders, made of thin sheet steel, ten feet in diameter and sixty feet high. But no sooty steamy cloud comes out of the top and if you looked down into one of them you would not be choked with sulphurous fumes, and you would see no fiery flares at the bottom. All you would see would be a ten horse-power electric motor, which rotates the cylinder, yet the vessel is propelled with the force of a thousand horse-power engine. She has neither propellers nor paddle-wheels, neither furnace nor fuel, neither yards nor sails. Her only engine is the little Diesel for running the two electric motors inside the cylinders, and all that this needs is a little crude petroleum or tar-oil for its internal combustion.

The propulsive power of the ship is borrowed from the wind and she gets the best of it when the wind is not going her way, but blows abeam instead of astern. She can make headway against the wind only by tacking like a sailboat.

Since the *Buckau* has no boilers she needs no bunkers, since she carries no coal she needs no stokers, and since she hoists no sails she needs no sailors. Even the helmsman can be dispensed with, for no rudder is necessary. The ship can be steered by changing the rate and direction of the rotation of the cylinders, and this the captain might control by pressing buttons on the bridge. Reversing the rotors backs the boat. Running one rotor around one way and the other the opposite way turns the boat about as on a pivot. It would seem that such a ship would require no bigger crew than a bicycle. Anyhow the elimination of the boilers and the bunkers and the quarters of the crew should leave a lot of room for cargo and passengers.

The question of how the queer craft would behave in a heavy sea was settled on January 6, when the *Buckau* steamed out of harbor, no, I should say sailed out, no, I should say, rotored out, and made nine knots an hour in spite of, and with the aid of, a twenty-knot wind.

We should have expected the rotor ship to have been an American invention for two reasons: first, because the principle involved is the same as our pitchers employ in putting the curve on a baseball in the national game; and, second, because this force has been thoroughly studied in American laboratories of aerodynamics. A recent technical paper by



DR. EDGAR T. WHERRY

Senior chemist of the United States Department of Agriculture, who has been able to treat soils so that sufficient acidity is produced for the growth of rhododendrons and trailing arbutus on ground which was previously too alkaline for this purpose.

Elliot G. Reid, of the Langley Memorial Aeronautical Laboratory, is devoted to "tests on rotating cylinders" and gives the formulas by which the force can be calculated and photographs showing how air currents behave in passing around a cylinder. If the cylinder is stationary, the wind divides and goes by equally on both sides, producing no effect except a push on the windward side. But if the cylinder is revolving the wind receives different treatment on the two sides. On the side of the cylinder where the rotary motion is in the same direction as the wind, the air is helped along and speeded up by the friction of the surface of the cylinder. Consequently, the air pressure is reduced on this side and a sort of suction is formed. On the side of the cylinder that is turning against the wind, the opposite effect is produced by the friction. That is, the flow of the air current is impeded, the air is compressed and its pressure on the cylinder is increased. The net result of diminishing the pressure on one

side and increasing it on the other is to produce a push acting on the cylinder at right angles to the wind, and it is this force that propels the Flettner boat.

The power of this cross-wind force depends upon the velocity of the wind, the height and diameter of the cylinder and its speed of rotation. The greater these are the stronger is the power developed. The Langley Laboratory finds that this force appears suddenly when the speed of the surface of the rotating cylinder rises to half that of the wind, and that thereafter the force increases steadily with the speed until the surface is moving twice as fast as the wind or faster. The experiments suggest that if the rotating shaft is made in the shape of a Greek cross instead of a smooth cylinder a greater cross-wind force may be produced, though it requires more power for rotation. The National Advisory Committee for Aeronautics has been engaged for a year in the investigation of the possibility of equipping airplanes with rotating cylinders, so as to utilize this cross force to impart a lift to the machine instead of depending wholly on the angle of the winds.

But neither our baseball fans nor our aviation experts have applied the principle to ship propulsion. So Anton Flettner has a free field and if his invention works as well as the German papers claim, he may appear before long in one of our ports with the ten thousand ton sailless ship that he plans to construct for transatlantic trade. It will be as strange an apparition as the submarine that bobbed up at Baltimore loaded with German dyes and drugs during the war, and it will be much more welcome.

ATTEMPTS AT ARTIFICIAL GOLD

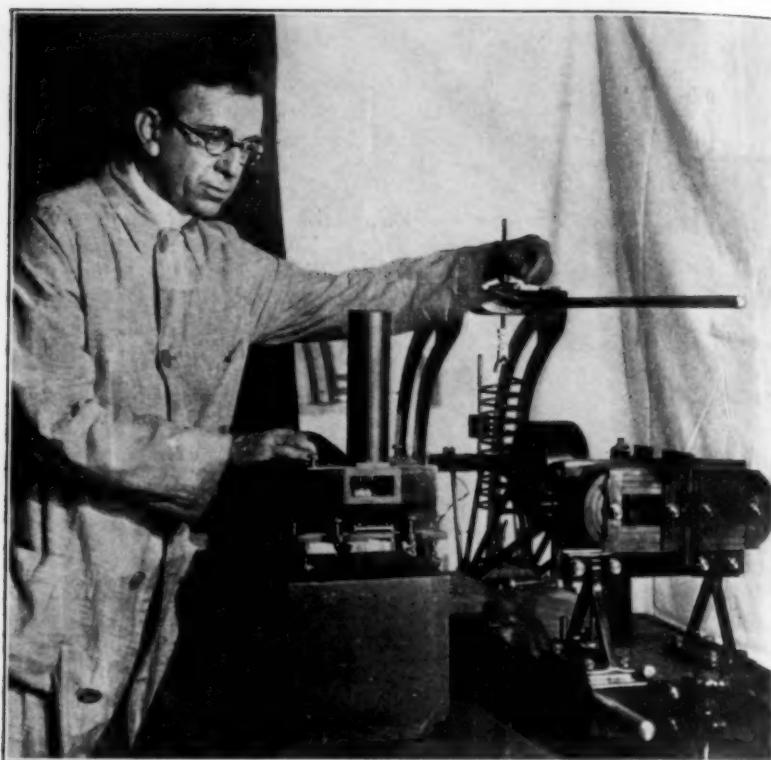
FOR some three thousand years, off and on, chemists have been trying to make gold out of the baser metals. Just now they are on the quest again with as high hopes as the medieval alchemists and with better reason. We now know that some atoms can be broken to pieces and that some elements can be transmuted into others. The metal radium decomposes spontaneously into the gas helium and the metal lead. Professor Rutherford has split up the nitrogen atom into helium and hydrogen. The helium atom weighs 4 and the hydrogen atom weighs 1. The helium is supposed to be made by the combination of 4 hydrogen atoms.

Now if you subtract the weight of the gold atom (197) from the weight of the mercury atom (201) you get 4. So it would seem that if you could knock out from the mercury atom a helium atom, or its equivalent, 4 hydrogen atoms, you would get gold.

But can you? That is the question. This may be, like many another chemical reaction, easy to write out on paper yet impossible to accomplish in the laboratory. But two chemists, a German and a Japanese, say that they have done it.

Professor A. Miethe, of the Photochemical Department of the Berlin Technical High School, who has been for years studying the discoloration of minerals and glass by ultraviolet light, found that the mercury vapor lamps used as a source for these rays ceased after a time to work owing to the deposit of a sort of soot on the quartz glass wall. He tested this deposit and got indications of gold.

Now it is not surprising to find a trace of gold in commercial samples of mercury, for mercury is one of the few liquids that will dissolve gold and is used to extract the precious metal from sand or ores. But the mer-



PROFESSOR FRANCIS A. TONDORF

Seen experimenting at Georgetown University with the new Galitzin vertical seismograph for the detection of earth tremors.

cury in the lamps had been twice distilled to free it from all impurities and on analysis showed no trace of gold until after it had been subjected to the prolonged action of the electric current in the lamp. The quartz, the iron and the carbons of the lamp were also analyzed and pronounced gold-free. Miethe sent samples of these and of the mercury, before and after using in the lamp, to Professor Haber, the inventor of the Haber process for fixing nitrogen, who has been interested in the extraction of gold from sea water and had developed a very delicate method of estimating gold in minute amount. He reported finding gold and in some cases silver in the samples that came from the lamps. The amount varied from one to fifty-two parts in a billion parts of mercury.

From these experiments, which Miethe has carried on with his assistant, Dr. H. Stammreich, since last April, he concludes that some of the atoms of the mercury have been crumbled away by the electric current passing through the vapor, leaving gold as a residue. In his lamps he used 170 volts between the electrodes and ran currents from 400 to 2,000 watts for periods of 20 to 200 hours.

From the other side of the world comes the report of similar success in the manufacture of gold artificially. Professor Hantaro Nagaoka, of

the Tokyo Imperial University, has published a photograph of a deposit of gold which he obtained by running a mercury lamp for more than 200 hours under a voltage of 226. The gold obtained amounted to a milligram and a white metal that appears to be platinum was also produced.

In the United States, Professor H. H. Sheldon, of New York University, is engaged in repeating these experiments and doubtless many others are quietly carrying on the quest.

But there is as yet no apparent reason for the alarm that synthetic gold will upset the standard of the world's currency. The process, if possible, is too expensive to be profitable. Although gold is more than three hundred times as costly as mercury, yet the electric current would cost more than the value of the gold produced. This is likely to remain true, however much the efficiency of the apparatus is improved. Professor Miethe expressly warns the public that his discovery of the possibility of decomposing the mercury atom has no commercial importance and that speculation in this direction is rash and premature. There is no ground for the suspicion that the Germans are secretly manufacturing gold with intent to pay off all their war debts before the rest of the world learns how. If the aim is to produce wealth it would be much more profitable to find out how to get energy out of the atom than how to transform the elements by putting energy into the atom.

FLYING MOUNTAINS OF GRASSHOPPERS TWENTY-FIVE trillion grasshoppers; forty-four million tons of them; covering an area of 2,280 square miles; all day long passing a given point. These are the figures given for a swarm making its migration from Africa to Arabia across the Red Sea on November 25, 1889, and the British naturalist, Dr. G. Caruthers, who observed the flight, adds that it was not one of the largest swarms. He fails to furnish the figures on a real big one, perhaps because of inadequate facilities for taking a census of such a flighty population.

But the swarm that passed over Pretoria on May 25, 1891, is more generously and more accurately, or at least more definitely, estimated as composed of 130,842,144,000,000 individual insects. This swarm is said to have filled twelve cubic miles of space in the air.

The swarm that invaded Algeria in "the grasshopper year" of 1866 is estimated to have totaled 50,000 tons live weight on the wing. Apparently the insects were not counted in this case, but a count of the natives who died of starvation in consequence of their devastations is reported as 200,000.

On the island of Cyprus, in 1883, the lady locusts laid five billion cases of eggs. I don't know how many eggs constitute a case, in this case, but the total weight of the lay is estimated at 4,000 tons.

No statistics are given as to the number of those who constituted the eighth plague of Egypt, but the Bible tells us that:

They covered the face of the whole earth, so that the land was darkened; and they did eat every herb of the land, and all the fruit of the trees which the hail had left; and there remained not any green thing in the trees, or in the herbs of the field, through all the land of Egypt.

I believe all these stories, and I would believe bigger ones if I could find them in any book at hand, for I can remember the grasshopper year of 1876 in Kansas. I can not give the number of these Colorado tourists,

because I was then too young to count over a billion, but I know that they darkened the land like a storm cloud and did eat every herb of the land and sent back to live with wife's folks thousands of hopeful young settlers in the western commonwealth. We called them "grasshoppers," not "locusts," and I ought to know what they are since I have seen and swallowed them, and I am pleased to note that the *Encyclopedia Britannica* confirms our western term.

I can add a detail of the grasshopper plague not mentioned by the author of *Exodus*, that they were so numerous as to stop the trains by greasing the track. Nowadays grasshopper grease is being used for lubricating airplane engines, a use we never thought of in 1876. It was recently reported that eighteen tons of dried locusts were shipped from South Africa to Holland for the extraction of the oil, which is said to retain its liquidity at very high altitudes.

It is nothing unusual to find great quantities of insects, especially grasshoppers, buried in snow fields and glaciers in the mountains. A very notable example of this is Grasshopper Glacier, in the Absaroka Mountains, a few miles north of Yellowstone National Park. The face of this glacier is marked with stratum after stratum of grasshoppers, and there are places on its surface where one can dig down a few inches with his fingers, and literally bring up solid handfuls of legs, heads and other parts of grasshopper shells. Presumably great swarms of insects attempting to cross the glacier have been chilled and trapped, and subsequent falls of snow have incorporated their bodies into the ice.

The most amazing thing to a chemist is the gigantic scale and swiftness of this production of grasshopper meat. The estimate given for the weight of the Red Sea swarm is some seventy times the weight of all the copper mined in America in a year. That is to say, it would take us seventy years to produce copper enough to balance the grasshoppers produced in seven weeks in this locality alone. Biology is still far ahead of metallurgy as a large scale industry. A green crop converts the carbon, nitrogen, hydrogen and oxygen of the air and water into plant protoplasm, and then comes a flying cloud and in a few seconds all this is gone into grasshoppers and the ground is bare.

It is not a simple process for producing a single element, like the smelting of copper from its ore, but more like the operation of an automobile factory. A grasshopper is a more complicated machine than an automobile and even Ford can not catch up with the grasshopper in quantity production.